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SURFACE EFFECT SHIP STRUCTURAL PRODUCIBILITY. PART II.(U)

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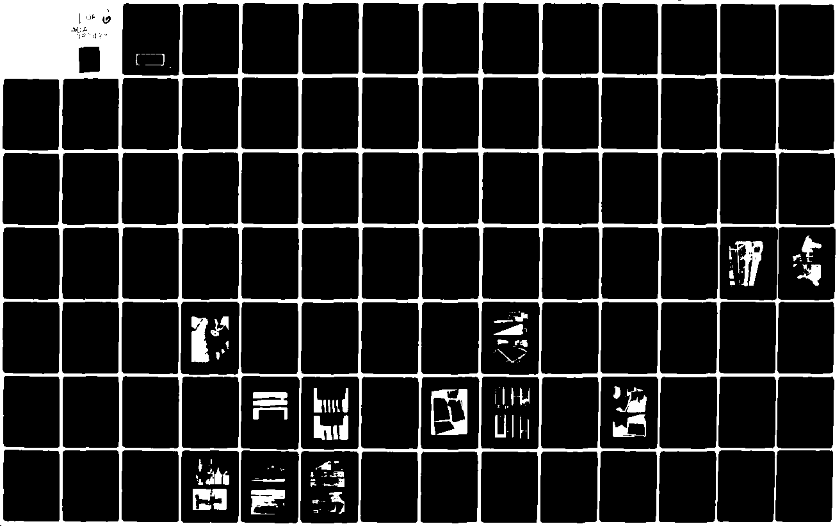

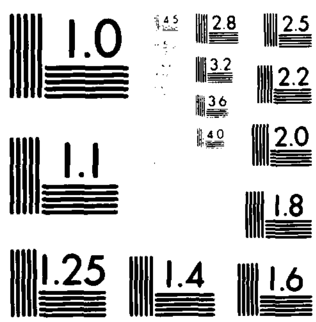

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APPENDIX B

1 / INTRODUCTION

This final report, which combines the functions of both test report and test data analysis and correlation report, documents the testing program implemented to obtain key structural design and verification data for the 3000 ton Surface Effect Ship (3KSES). Under this program, static and fatigue tests were conducted on a variety of panel and element specimens representative of the 3KSES hull structure. Panel specimens encompassed welded plate coupons and single-bay length stiffened panels. The larger, more complex element speciments included three-bay length stiffened panels and segments of deck/transverse bulkhead intersections. With minor exceptions, all testing was conducted in accordance with Test Plans TTP00016A and TTP00017 (Reference 1 and 2, respectively), as approved by NAVSEA.

A principal task within the structural design effort for the 3KSES involved the translation of loads and other design criteria into efficient structural arrangements and scantlings. To assure structural integrity, the detailed hull stress analysis must be based on substantiated strength values for structural components and joints fabricated to represent 3KSES production quality. The Structural Panel and Element Test Program described herein was conducted to provide those substantiated values.

The influence of specific manufacturing procedures and tolerances on structural performance constituted a significant aspect of this testing program. As a result, the test data provided quantitative values for structural load carrying capacities related to specific manufacturing processes and tolerances. This data was necessary to define certain of the fabrication and inspection standards incorporated in the 3KSES hull structure fabrication document, Reference 3, which will be imposed during hull construction. Use of this data also enables stress engineers to evaluate certain analytical methodology for more accurately predicting hull structural response.

The Panel and Element Test Program described herein was conceived and conducted as a logical extension of the effort completed furing the 3KSES Advanced Development Program (Technical Development Area H-5). As such, the program was aimed at being fully responsive to the knowledge gained and technological achievements developed from the previous efforts. The total scope of the present program was intended to provide sufficient data to support go-ahead on the construction phase of the 3KSES.

This final report is structured and organized to document all aspects of the Panel and Element Structural Test Program. Background information and rationale for the planned tests and definitions of the test program objectives and scope are included. Also presented are descriptions of all test specimens, test facilities and setups, test fixtures and equipment, instrumentation and test procedures. Recorded test data and interpreted test results are presented along with correlations of the results to the other data and analytical predictions as applicable.

This report fulfills the requirements of Paragraph 3.2.2 of the 3KSES Contract Statement of Work, Reference 4, and the requirements of Exhibit Line Item No. E02Z of the Contract Data Requirements List (CDRL). This docoment has also been prepared in accordance with the applicable requirements of Data Item Description No. UDI-S-23272C.

1.1 BACKGROUND

During the Advanced Development Program, structural characteristics of representative SES hull structure panels were determined empirically and compared to analytical predictions. The test articles employed in all of those tests consisted of plating stiffened with two extruded tee stringers, typifying a section of SES deck structure as shown in Figure 1-1. The panel specimens were designed and fabricated to semulate a spectrum of ship production conditions. These specimens were evaluated for the effects of various parameters including distortions, joint fit-up, weld quality, weld repairs, reinforcing doublers, and post-weld processing such as blending and/or peening of the weld reinforcement. Various combinations of longitudinal and transverse plate and tee weld joint configurations were tested to obtain a reasonably adequate data base. Testing encompassed static tension, compression buckling, and tensile fatigue including crack propagation.

The above test program produced significant data on static tensile strength, compression stability, fatigue performance, assessment of crack langth critcality, and production and inspection procedures and standards. Based on the data accrued, design allowables and methods of analysis were demonstrated to be applicable to a carefully fabricated hull of tee stiffened panel structure. All of the above described work was accomplished within Technical Development Area H-5. References 5 and 6 are the principal reports documenting that effort.

The initial development of welding and fabrication techniques specifically related to lightweight aluminum SES hull structure was accomplished within Technical Development Area H-12. From that work, it was concluded that conventional gas metal arc welding using automation and weld pacer assistance (plus gas turgsten arc welding for areas of difficult access) can produce high-quality welds with minimal distortion at relatively high production rates. The H-12 program also demonstrated that precise difinition of welding procedures and careful execution in applying the procedures during the welding operation are required to attain the necessary quality. Reference 7 is the summary report documenting the H-12 program effort.

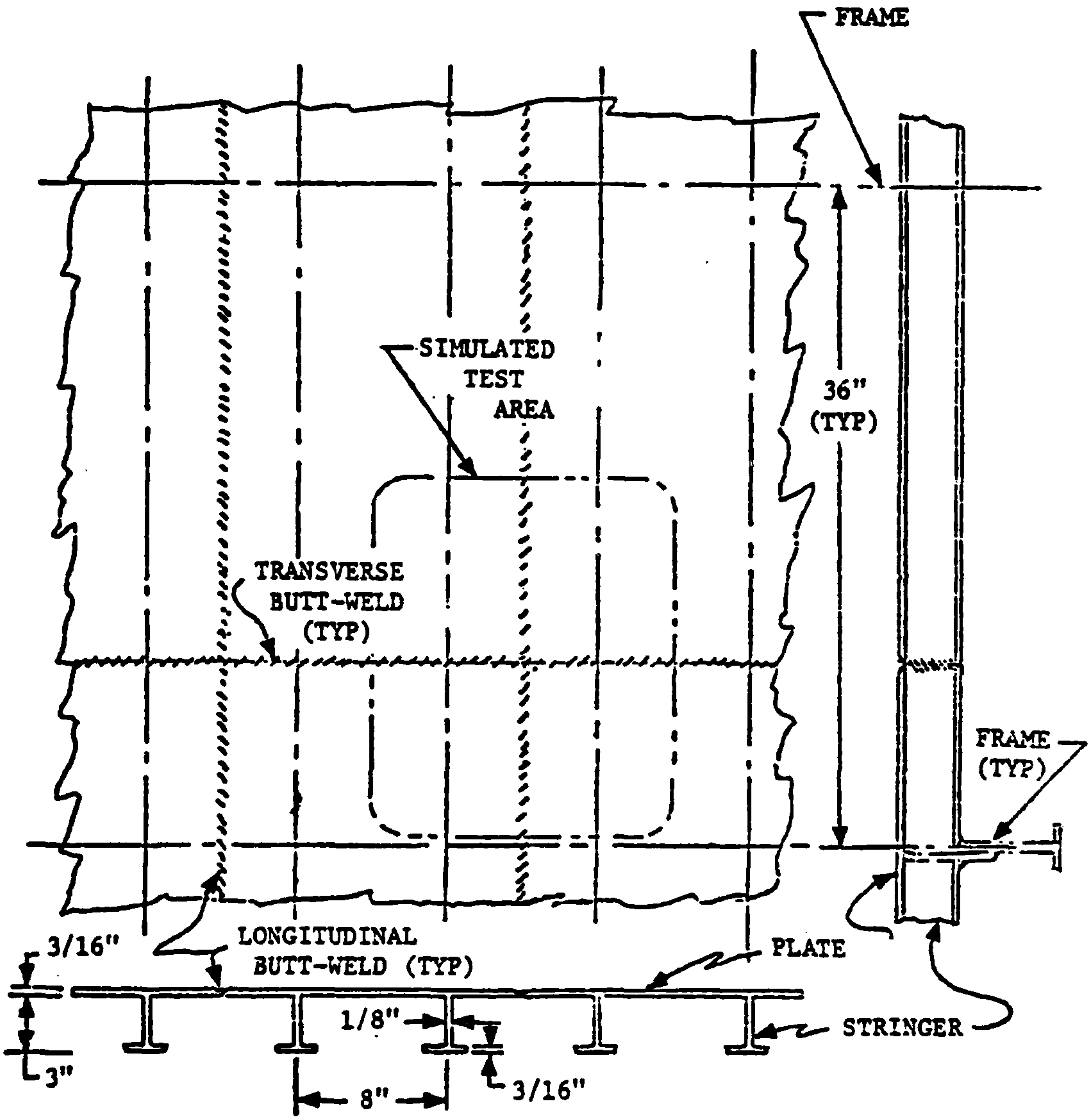


Figure 1-1. 2KSES Structure Represented by Typical H-5 Test Panel Specimen.

Since the completion of H-5 and H-12 testing, a number of significant changes in the 3KSES hull structural details were made to substantially enhance producibility. Principal among these was a shift from tee stiffened panels to flatbar stiffened panels for the amjor portion of hull structure. Also, additional welding development was accomplished resulting in further improved welding procedures and attendant weld quality compared to the levels reflected on the H-5 panels.

The panel and element structural testing program implemented under the 3KSES Part 1 contract and documented herein reflected these factors and provided an expanded data base required for ship design. For planning purposes this test program was divided into two parts, structural panel tests and structural element tests, as follows:

a. Structural Panel Tests

   The structural panel tests were devised as a logical extension of the Advanced Development Program to reflect updated 3KSES design details and fabrication technological developments. These tests addressed plating welded joints and representative single frame-bay length flatbar stiffened panels. Tests on numerous plating welded joints, representing a broad spectrum of these planned for use in the 3KSES hull structure, addressed the effects of various parameters including welding and weld repair methods, joint fitup and post-weld processing. Tests on the single framebay length stiffened panels addressed the effects of various eccentricities, weld repairs and joint improvement techniques. A principal aspect of the stiffened panel testing was aimed at providing data that can be used to verify or refine the methodology for analyzing this type structure under axial compression loading when certain types of accentricities are present. As depicted in Figure 1-2, the welded plating coupons and the stiffened panel specimens selected for testing represented various areas of typical 3KSES hull structure.

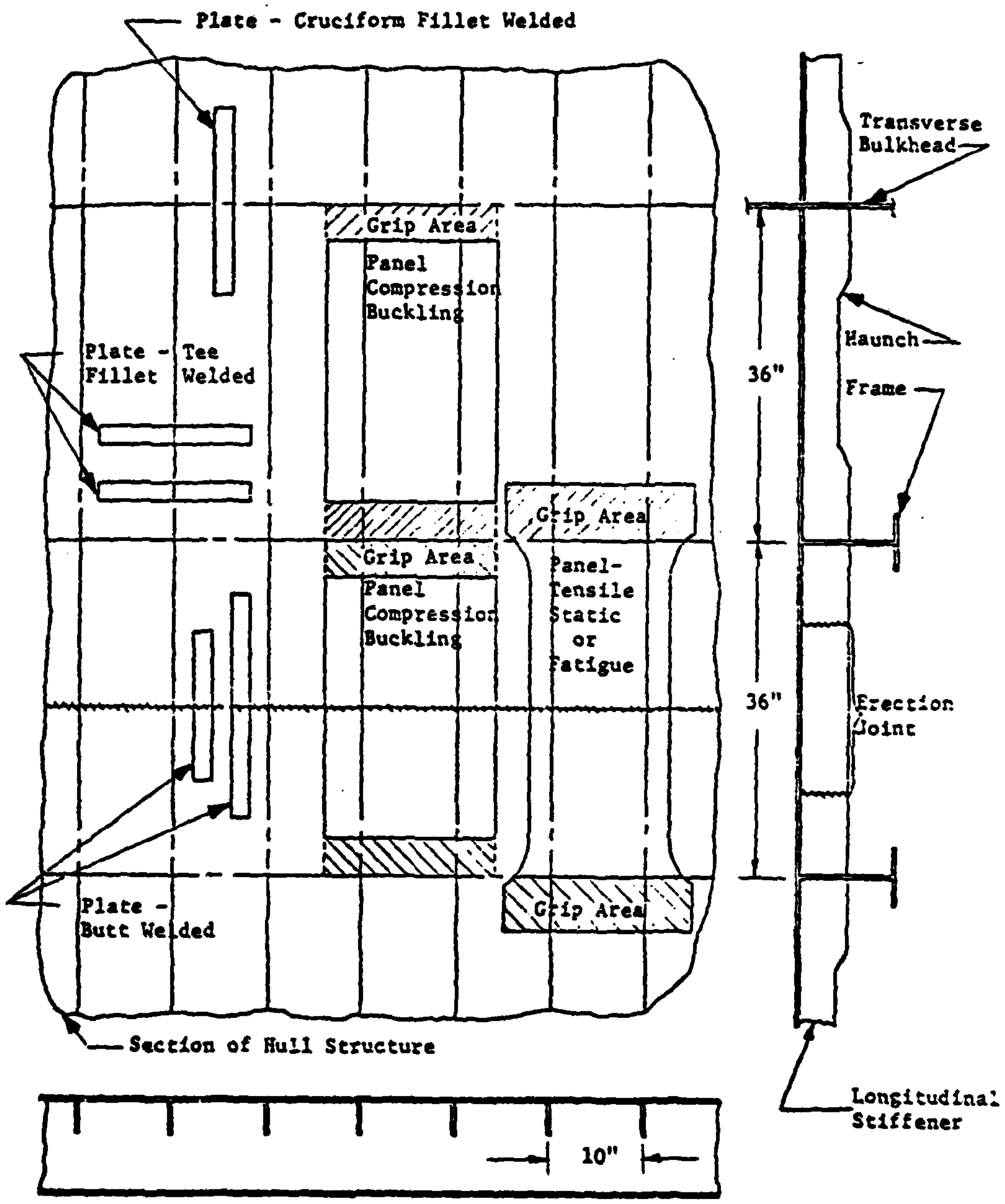


Figure 1-2. 3KSES Structure Segment Showing Orientation of Typical Plate and Panel Test Specimens.

b. Structural Element Tests

The structural element tests were developed as a logical extension of the single-bay stiffened panel tests to three length panels with boundary conditions and structural interactions more representative of the 3KSES hull structure. The three-bay panel testing was aimed at providing data to substantiate and/or refine the methodology for analyzing this type of structure under various combinations of axial compression loading and surface pressure. The structural elements testing also addressed the intersection of continuous deck structure with a transverse bulkhead when subjected to tensile loadings. Locations on the 3KSES structure which were simulated by the element specimens selected for testing are depicted in Figure 1-3.

1.2 OBJECTIVES

The comprehensive panel and element structural testing documented in this report was conducted to satisfy the following planned general objectives:

a. Validate or refine the tensile design allowables for welded plate joints, erection joints in stiffened panel structure and transverse bulkhead-to-deck intersections fabricated to various production quality standards;

b. Acquire data to validate or modify the analytical methodology used for predicting the axial compression strength of flatbar stiffened panel structure containing various types and degrees of eccentricities and distortions:

c. Develop improved weld repair and post-weld treatment procedures;

d. Provide data to assist in the definition of fabrication and inspection standards and procedures for the 3KSES hull structure fabrication document; and

e. Acquire information and data for use in preparing the in-service Hull Surveillance Plan.

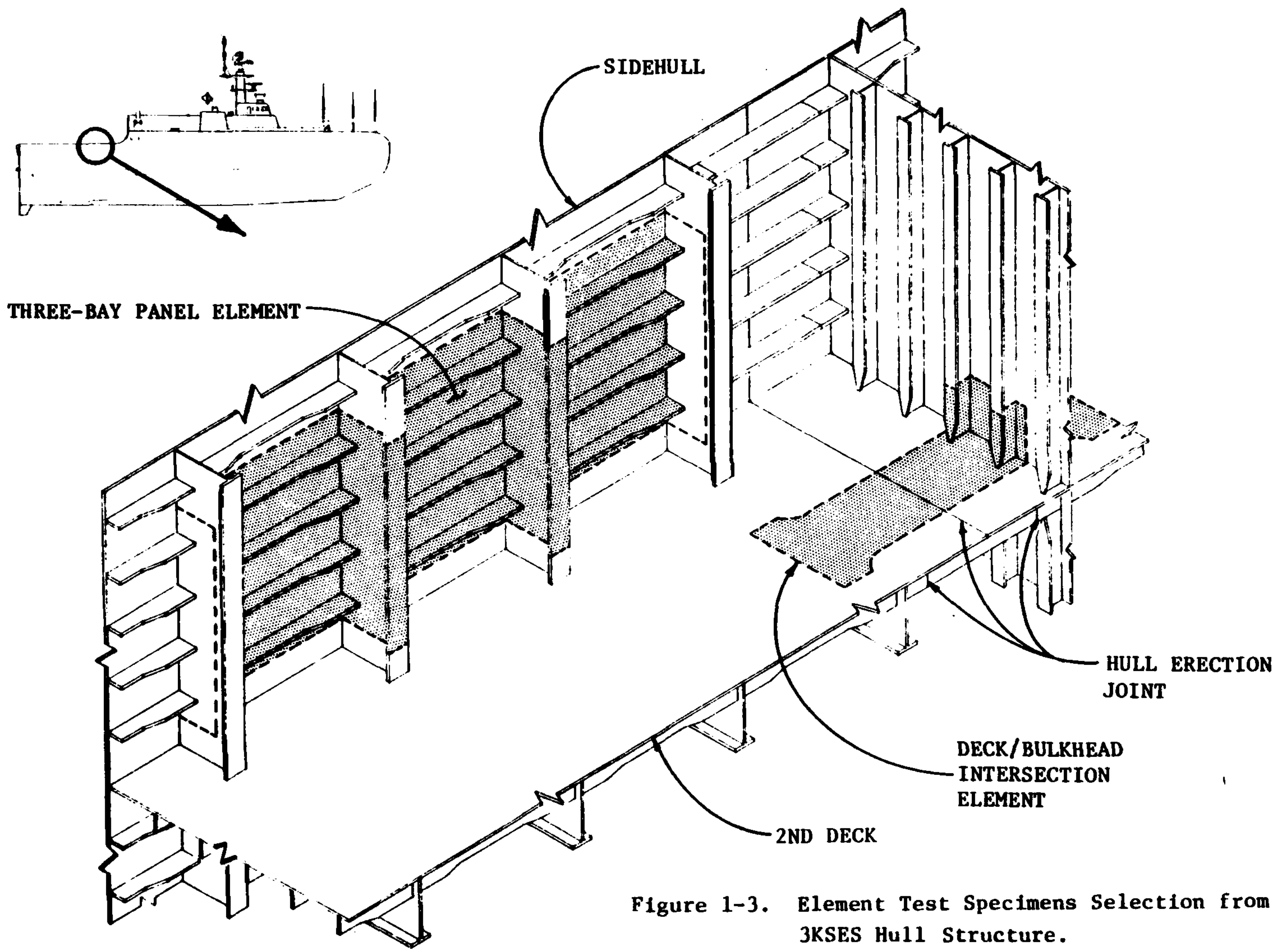


Figure 1-3. Element Test Specimens Selection from 3KSES Hull Structure.

The above general objectives encompassed a number of specific objectives which were as follows:

a. Verify the static and fatigue strengths of plating butt welds made using welding procedures suitable for 3KSES production. Conduct tests on joints covering a broad range of plating thicknesses anticipated for use in the 3KSES. Acquire data for welds made from one side and welds made from both sides to quantify the effects of joint mismatch, joint misalignment, unequal plate thicknesses, weld repairs, post-weld processing, retaining the as-welded reinforcement, and removing the weld reinforcement.

b. Verify the static and fatigue strengths of double fillet welds and groove tee fillet welds made using welding procedures suitable for 3KSES production. Acquire data to quantify the effects of weld repairs and post-weld processing.

c. Investigate weld repair procedures to achieve improved fatigue performance over that attained during the Advanced Development Program. Acquire data for single and multiple weld repairs with and without post-weld processing.

d. Investigate post-weld processing procedures including brush (rotary flapper) peening, shot peening, and weld reinforcement contour shaping. Acquire data to evaluate the effects of post-weld processing on the fatigue and static strengths of welds with emphasis on repaired welds.

e. Verify the tensile static and fatigue strengths and the axial compression strengths of typical 3KSES flatbar stiffened panels containing simulated assembly erection joints fabricated with various fitup eccentricities.

f. Conduct asial compression tests on several configurations of flatbar stiffened panels containing various types and degrees of eccentricities. Acquire data to substantiate or provide a basis for refining the analytical methods for predicting the

axial compression strengths of flatbar stiffened panels containing flatbar and panel distortions and eccentricities.

g. Obtain data to define the effects of distortions and deviations from fairness on structural strength.

h. Evaluate the effectiveness of the distortion removal techniques employed during panel assembly fabrication.

i. Verify the static and fatigue strength characteristics of structure that has been straightened after welding to remove distortions found excessive by the fairness criteria.

j. Conduct tests on stiffened panel specimens incorporating weld repairs and/or post weld processing to verify repeatability of the basic results obtained from the plating joint tests.

k. Evaluate the effects of adding bonded doublers or mechanically fastened doublers to improve joint fatigue strength.

l. Verify that weld inspection procedures and standards are adequate to detect deficient welds which excessively degrade structural integrity.

m. Define standards and establish static and fatigue strengths for various grades of deficient welds which may be acceptable in non-critical locations on the 3KSES hull structure. Weld deficiencies included porosity and lack of penetration/lack of fushion exceeding normal acceptance standards.

n. Acquire information relating to crack detection, and obtain crack propagation rate data from welded joint and stiffened panel fatigue tests.

o. Obtain data during specimen fabrication related to control of distortions including weld sequencing, assembly sequencing, and fixturing constraints.

p. Determine the static strength and buckling characteristics of flatbar stiffened panels spanning three frame-bay lengths.

(1) Determine panel strain (stress) distributions, buckling mode(s) and buckling load(s) to validate and/or identify areas of modification to the analytical prediction methods.

(2) Quantify the sensitivity of panel strength to bowed flatbar distortions under combinations of axial compression and external pressure loading.

(3) Determine the actual ultimate load-carrying capacity of each test panel under one critical test loading condition to evaluate post-buckling behavior.

q. Verify or refine the tensile static and fatigue design allowables for continuous flatbar stiffened deck structure at transverse bulkhead intersections. Include the effects of typical production alignment tolerances.

Results from the tests conducted to achieve these objectives are reported herein along with correlations to pertinent test data and theoretical analysis as applicable.

1.3 SCOPE

The overall scope of testing conducted under the panel and element program was essentially in accordance with the Reference 1 and 2 test plans. Minor deletions of certain planned specimens were more than offset by added specimens in other areas plus supplemental tests carried out in three areas beyond the scope of the test plans. These variations are further described below.

Testing was conducted on two basic types of panel specimens - welded plate joints and flatbar stiffened panels - and on two basic types of element specimens - three-bay length flatbar stiffened panels and flatbar stiffened deck/transverse bulkhead intersections. Tests on the panel specimens encompassed static tension, axial compression buckling, axial tensile fatigue, and bending fatigue. Tests on the element specimens encompassed static tension, axial compression buckling,

axial tensile fatigue, normal pressure, and combined loading. A matrix displaying the actual quantities of panel and element specimens with the corresponding types of tests conducted is presented in Table 1-1.

The scope of the panel and element program was considered the minimum necessary to demonstrate, through testing, the adequacy of design allowables for specific welded structure joints and the validity of buckling analysis methodology for flatbar stiffened panels. Test data was acquired to evaluate the effects of eccentricities on the buckling strength of flatbar stiffened panel structure under axial compression load only and combinations of axial compression with external pressure loading. The evaluated panel eccentricities included joint mismatch, stiffener offset misalignment, and stiffener lateral bowing distortions.

A portion of the planned testing was conducted to provide data related to fabrication and inspection standards and procedures for use in the Hull Structure Fabrication section of the Production Plan CDRL E00K(A), Reference 3. Tests were performed to establish acceptable limits for weld quality, weld bead contour, and structural fairness before and after welding. Weld strengths and efficiencies were established, and data was acquired for use in defining standards for the rejection of deficient welds. Testing was also conducted to provide guidelines for accepting, within limits, deficient welds in certain locations on the structure. A net reduction of 20 in the originally planned number of tensile static and fatigue coupons addressing deficient welds proved necessary after repeated unsuccessful attempts were made to produce valid lack of penetration/lack of fusion imperfections in butt welds made from two sides.

The originally planned scope of testing on the three-bay panel elements was expanded to include tests to failure under axial compression load only. In addition, testing was conducted on the fourth specimen, originally planned as a spare.

Table 1-1. Panel and Element Structural Test Matrix

	SPECIMEN DESCRIPTION AND TEST TYPE	QUANTITY
WELDED PLATES	BUTT JOINTS WELDED SINGLE PASS FROM ONE SIDE	
	Axial Tension Static Tests	22
	Axial Tension Fatigue Tests	93
	Bending Fatigue Tests	27
	BUTT JOINTS WELDED FROM BOTH SIDES	
	Axial Tension Static Tests	9
	Axial Tension Fatigue Tests	24
	Bending Fatigue Tests	3
	FILLET WELDED TRANSVERSE CRUCIFORM JOINTS	
	Axial Tension Static Tests (Cruciform)	9
	Axial Tension Fatigue Tests (Tee)	22
	Axial Tension Fatigue Tests (Cruciform)	24
	BUTT JOINTS WELDED SINGLE PASS FROM ONE SIDE WITH WELD INPERFECTIONS	
	Axial Tension Static Tests	29
	Axial Tension Fatigue Tests	59
STIFFENED PANELS	BASIC (HAUNCHED STIFFENER) CONFIGURATION	
	Static Compression Tests	4
	ERECTION JOINT CONFIGURATION	
	Static Tension Tests	4
	Static Compression Tests	22
	Tensile Fatigue Tests	23
ELEMENTS	THREE-BAY FLATBAR STIFFENED PANEL	
	Axial Compression Static Test	
	External Pressure Static Test	4
	Combined Loading Static Tests	
	FLATBAR STIFFENED DECK/TRANSVERSE BULKHEAD INTERSECTION (WITH ERECTION JOINT)	
	Axial Tension Static Test	2
	Axial Tension Fatigue Test	3

Developmental testing was conducted in the areas of post-weld processing, weld repairing, and structural straightening. Post-weld processing included weld bead recontouring, rotary flapper (brush) peening, and shot peening. Weld repairs encompassed single and multiple repairs, with and without post-weld processing, and the use of reinforcing doublers. Structural straightening methods included surface shrink welds and mechanical means such as bydraulic jacking, prying, and the use of mallets.

Crack detection and crack propagation rate data was recorded during the stiffened panel fatigue tests for use in the future development of an in-service Hull Surveillance Plan to be included in the Ship Information Book (CDRL E02J). The panel fatigue tests also provided data which can be utilized in selecting recommended inspection levels to be included in the Surveillance Plan.

During the course of the panel and element testing, supplemental tests were performed in three separate areas beyond the scope of the Reference 1 and 2 test plans to provide needed design engineering data. In the first area, static tensile tests were conducted on coupons cut from a 5456-H111 aluminum alloy extrusion to determine extrusion directional mechanical properties. The second area of supplemental testing was conducted to determine the influence of high strain rates on the tensile properties of butt welded joints in 5456-H117 aluminum alloy plate. Tests were performed at strain rates ranging from the standard static tensile test rate of 0.05 per minute up to a maximum of 1.0 per second. The objective of these tests was to determine if increased design allowables could be employed for ship impulsive loading conditions. The third series of supplemental tests was conducted to determine allowable limits for 3KSES sidehull fence bearing on drydock cap blocking. This series encompassed bearing tests on both Douglass Fir and White Oak cap block specimens in the dry as-received and seawater-soaked conditions loaded by forms duplicating the 3KSES fence cap contour extremes. A matrix summarizing the supplemental

tests including actual specimen quantities and the corresponding types of tests is presented in Table 1-2.

A chart depicting the extensive utilization of data acquired from the panel and element structural test program is presented in Figure 1-4.

Table 1-2. Supplemental Structural Test Matrix

TEST DESCRIPTION	SPECIMEN DESCRIPTION AND TEST TYPE	SPECIMEN QUANTITY
EXTRUSION DIRECTIONAL PROPERTIES	BASE METAL COUPON	
	Web Longitudinal Static Tension Test	4
	Web Transverse Static Tension Test	4
	Flange Transverse Static Tension Test	4
HIGH STRAIN RATE	BUTT JOINTS WELDED SINGLE PASS	
	Axial Tension Static Test	6
	Axial Tension Accelerated Strain Rate Test	18
KEEL CAP BLOCK BEARINGS	CAP BLOCK TIMBERS	
	Bearing Static Test	7

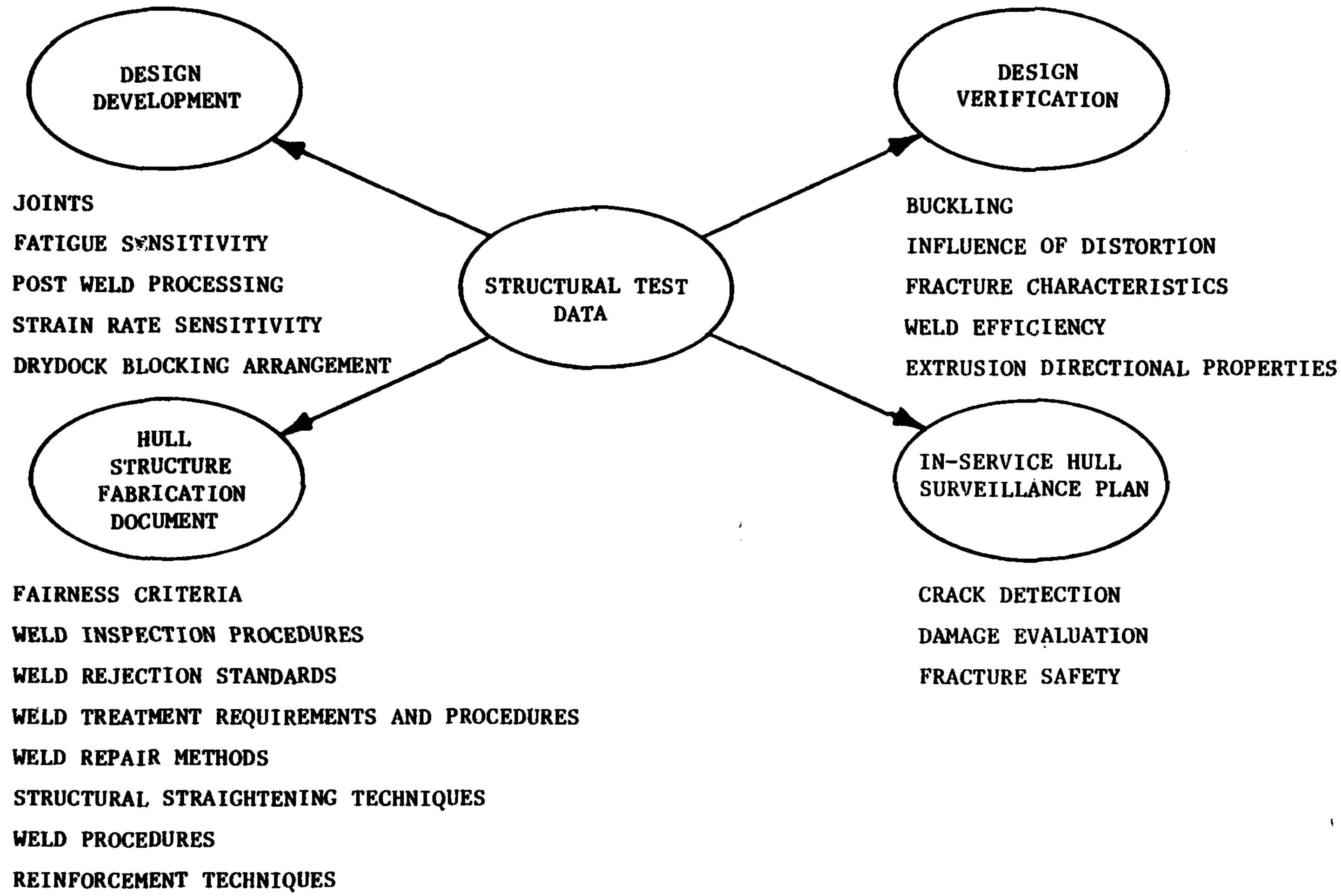


Figure 1-4. Structural Test Data Utilization Chart

APPENDIX B

2 / APPROACH AND ORGANIZATION

2.1 APPROACH

A systematic approach was taken in the execution of the Panel and Element Structural Test Program to achieve the various test plan objectives. This approach encompassed the performance of tests progressing from simple coupons to basic stiffened panels and then to more complex structural elements as described below. This "building block" approach permitted the significant findings from the earlier tests to be utilized in later tests as the program progressed.

2.1.1 COUPON TESTS -- Initial testing was performed on butt and fillet welded plate coupon specimens to validate the 3KSES design tensile strength properties with emphasis on evaluating the effects of various fabrication parameters on these properties. Tension yield strengths (both for 2-inch and 10-inch gage lengths) and tensile ultimate strengths from the test results provided validation for the strength properties specified in Reference 3 for 3KSES design and analysis. Static tests were conducted to determine the effect of various fabrication parameters; however, the majority of these specimens were tested in fatigue which was considered to be a more sensitive indicator of the effects of these parameters.

Static and fatigue tests were conducted on welded plate coupons with variations in joint design and fit-up, with the weld reinforcement

intact and removed, in as-welded and repaired conditions, and with various degrees of weld imperfections. In addition, fatigue tests were conducted on specimens which had been shot peened and rotary peened to determine the optimum post-weld processing techniques. Transverse static tension tests were conducted on cruciform configuration fillet welded specimens in the as-welded condition, and fatigue tests were conducted on transverse tee and transverse fillet welded coupons. The fatigue tests included specimens with variations of fillet size and bead geometry, in the as-welded and repaired conditions, and with and without peening in which the optimum peening process, as determined from the butt welded plate coupons, was used.

2.1.2 STIFFENED PANEL TESTS — Testing was next accomplished on single bay stiffened panel specimens as a logical progression from coupons to the basic 3KSES structural configuration. The panel specimens were stiffened with two flatbar stiffeners which were fillet welded to the plate on 10-inch spacing. separate groups of these specimens were tested in static tension, tensile fatigue and in column compression. The effects of various eccentricities were emphasized in the compression tests, and the fatigue tests evaluated the effects of panel straightening and butt joint mismatch, as well as single and multiple repairs. The static tensile tests validated the attainment of material tension design allowables for correlation with the properties derived from the welded plate coupon tests. The results of the stiffened panel tensile fatigue tests also provided a data base for correlation with the results of the coupon tests. (The coupon fatigue test results were used to establish the upper range of the maximum local tensile stress for the stiffened panel tensile fatigue tests.)

Except for two static compression specimens, all of the stiffened panel test specimens were fabricated with a typical 3KSES erection joint configuration. Structural parameters included four stiffener/plate thickness combinations with geometric eccentricities which included bowed and bowed and straightened stiffeners, butt joint mismatch and misalign-

ment, single and multiple repairs, and optimum peening. In addition to the all-welded panels, specimens with mechanically fastened doublers over unwelded stiffener butt joints were tested in static tension, tensile fatigue and static compression to evaluate this design as a potential alternate for fabricating the erection joint. Also, a single configuration consisting of doublers bonded over weld repairs in the stiffeners and plate butt joints was tested in tensile fatigue to evaluate this approach as a potential in-service repair technique.

The stiffened panel specimen compression test results were correlated to analytical strength computations as described in Section 5 of this report.

2.1.3 DECK/BULKHEAD ELEMENT TESTS -- Progressing to a more complex structure, a configuration similar to the 3KSES deck-bulkhead intersection was tested with loads applied in the plane of the deck. This structural element configuration included the deck erection joint and adjacent transverse bulkhead intersection with replicates tested in static tension and in tensile fatigue. Both the static tension and tensile fatigue tests were conducted until an initial failure occurred; then repairs were made, and testing was restarted and continued until ultimate failure occurred. The results of these tests also provided a data base for correlation to the results of the panel and coupon tests.

2.1.4 THREE-BAY ELEMENT TESTS — Final tests under the formally planned Panel and Element Test Program were conducted on stiffened panel structural elements which were three bays in length. These elements were configured with transverse tee frames on three-foot spacings and with four haunched flatbar longitudinal stiffners on ten-inch spacings. These specimens were tested with axial compression and lateral pressure loads applied separately and in various combinations. Tests were conducted within the elastic region and to failure on four test specimens. The results were correlated to the 3KSES analytical methods as described in Section 7 of this report.

2.1.5 SUPPLEMENTAL TESTS -- Supplemental tests, not included in the formally submitted test plans (References 1 and 2) were conducted to provide additional information needed for the 3KSES design process. These tests included (1) tension tests of extrusion directional properties, (2) high strain rate tension tests, and (3) keel block bearing tests.

2.2 ORGANIZATION

This test report provides documentation of the fabrication, testing, test data, test data analysis and correlation, conclusions and recommendations resulting from the 3KSES Panel and Element Structural Test Program. Section 3 of the report describes the various processes and procedures (including inspection) associated with the fabrication of the test assemblies. Each of Sections 4 through 8 is a complete test and correlation report for the welded plate coupons, stiffened panels, deck/bulkhead elements, three-bay panel elements and supplemental tests, respectively. Additional recorded data for the various tests are contained in the appendixes.

3 / ASSEMBLY FABRICATION

3.1 GENERAL

Except for two of the supplemental test series, the sources of all specimens in the panel and element structural test program were specially fabricated welded assemblies. These welded assemblies were designed and fabricated utilizing planned 3KSES Procedures and controls, as applicable, for drawing preparation and release, detail production planning, material control, fabrication and welding, inspection and disposition of non-conformances, and maintenance of records. The detail fabrication requirements for the various assemblies are contained in the following drawings, copies of which are provided in Appendix A:

TT802015A Plate Weldments - Transverse Butt
TT802017A Plate Weldments - Transverse Cruciform
TT802018A Plate Weldments - Transverse Tee
TT802021A Plate Weldments - Transverse Butt Weld Imperfections
TT802024A Fabrication Assembly - Flatbar Stiffened Panels
TT802032 Fabrication Assembly - Deck/Bulkhead Intersection
TT802041 Test Article Assembly - Three-Bay Panel Element

This section presents the methods, procedures and techniques used to fabricate the welded plate and stiffened panel assemblies from which the various test specimens were sectioned.

3.2 MATERIAL AND MATERIAL PROCESSING

3.2.1 MATERIAL -- All welded assemblies were fabricated from 5456-H116/H117 aluminum alloy sheet and plate. The filler material was type 5556 bare aluminum welding electrodes conforming to MIL-E-16053L, Reference 8, in the "shaved" condition. The base material was taken from several heats and was verified by chemical analysis. The filler material was verified by all weld metal tension tests and bare wire tension tests.

3.2.2 MATERIAL PROCESSING -- With the exception of the final group of plate weldments produced with intentional butt weld imperfections, all sheet and plate material was chemically cleaned by an alkaline etch method. This method was also used to chemically mill some of the material to provide stock thicknesses that could not be readily procured in the small amounts required for this test program.

During the waning phase of fabricating test assemblies, it was determined that the advantages gained from chemically cleaning all plate material did not warrant the additional expense involved, and a decision was made to discontinue this process. This decision was supported by the fact that the etch cleaning process did not adequately prepare the weld edge surfaces for welding and would not completely remove heavy water staining. Since additional effort would be required to remove the excess water stains, and weld edge preparation was required regardless of the condition of the plates, the elimination of the chemical process cleaning was not considered detrimental. The assemblies which had not been fabricated at the time chemical cleaning was discontinued, i.e., the final plate butt weld imperfection assemblies, were fabricated in the mill-finish condition.

Edge trimming in preparation for welding was accomplished as prescribed for production welds in Reference 3. The joint faying and contiguous surfaces were solvent cleaned and wiped followed by mechanical cleaning using a power driven stainless steel wire brush. Welding was

usually performed within 8 hours after joint preparation; however, in some of the larger assemblies a longer period of time (i.e., up to 5 days) elapsed from cleaning to final welding.

3.3 FABRICATION AND WELDING

Fabrication details and allied processes are presented in the following paragraphs. A detail planning sheet package was prepared for each welded assembly. These planning sheets contained step-by-step instructions for material accumulation and preparation, weld joint configuration, assembly and welding sequences, welding procedures, inspection schedules and other specific details associated with each assembly. Discrepancy reports, including dispositions, were prepared for all nonconformances, and these reports, along with the planning documents, provided a record of activities associated with the fabrication of each assembly.

3.3.1 JOINT DESIGN AND WELD PROCEDURES -- Various joint designs, as depicted in the fabrication drawings, were used in the assembly fabrication. In general, all butt joints in plating were as follows:

Thickness (Inch)	Joint Design
Less than 0.313	Square or grooved butt welded from one side.
Greater than 0.313	Square or grooved butt welded from both sides.
0.313	Welded from one side or two sides as specified on the drawings.

Butt joints in stiffeners were welded from both sides regardless of the thickness. All tee joints were double fillet joints except full pentration tee joints were made on two of the assemblies (TT802017-113 and -115) which were used for fatigue test specimens. Welding procedures were developed for each joint design for the various thicknesses and welding equipment used. The various procedures developed are listed in Appendix B.

3.3.2 WELDING EQUIPMENT — Semi-automatic, machine and automatic Gas Metal Arc (GMA) pulsed arc welding equipment identical to or similar to the equipment planned for welding 3KSES structures was used for welding the structural test assemblies. The basic welding equipment is described in detail in Appendices A thru E of Reference 2. A brief description of each welding method, exclusive of power supplies, follows below.

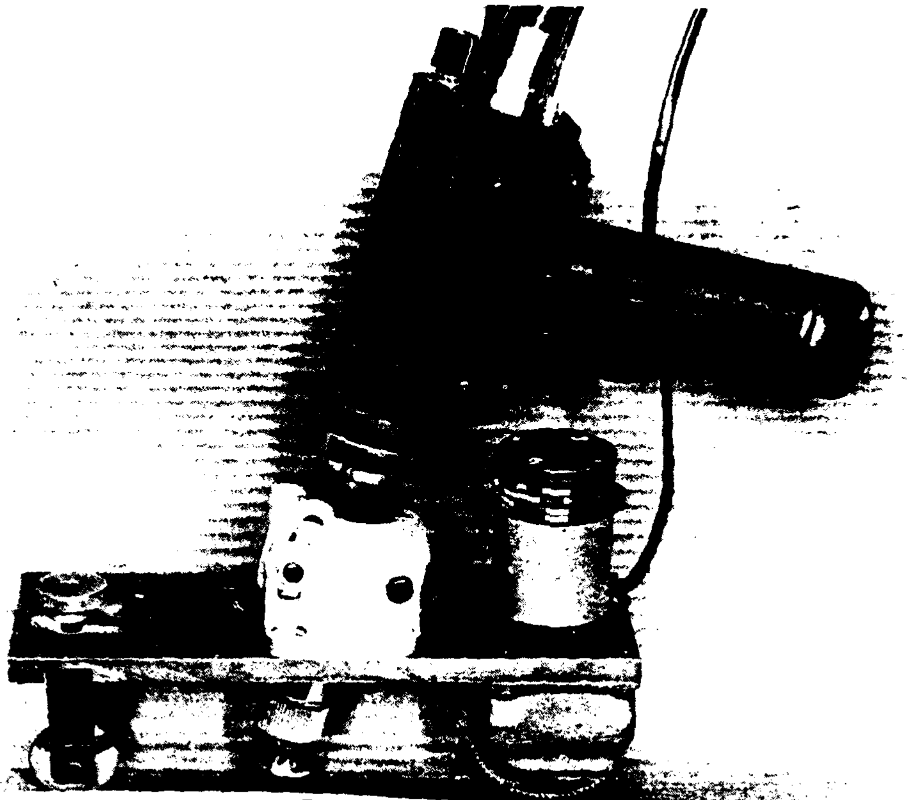
The automatic welding equipment consisted of a welding table with an overhead beam and traveling carriage equipped with single or twin-arc welding heads. Pneumatic operated plungers were incorporated to clamp the workpiece to the table. Welding was performed using preset parameters under the observation of a welding operator. This equipment is illustrated in Figure 3-1.

The machine welding equipment consisted of accessory units which clamped the semi-automatic GMA welding gun in a fixed position and automatically controlled the gun attitude and the rate of travel. The weld parameters were preset and each machine was operated under the constant observation and control of a welding operator. Two types of this equipment were used - a Pacer™ for butt welds and a Wiggler™ for fillet welds. These units are illustrated in Figure 3-2.

Welding guns which controlled the filler wire feed rate along with associated controls and power supplies comprised the semi-automatic welding equipment.

Because of improved chances for reproducibility and less dependence on human factors, the welds in this program were made, wherever practicable, with machine or automatic welding equipment. Semi-automatic welding equipment was used only on short welds such as the butt joints for the drop-in stiffener sections across the simulated hull erection joints, the attachment of the frames to the deck panels for the three-day panel assemblies, and other areas which were inaccessible for the Pacer™ or Wiggler™.

Figure 3-1. (770403-1) Automatic Panel Welding Equipment



(a) (760166-3) Pacer™ Butt Welding Accessory Unit

(b) (780451-9) Wiggler™ Fillet Welding Accessory Unit in Operation

Figure 3-2. Butt and Fillet Welding Machines

In addition to the above GMA welding processes, the Gas Tungsten Arc Welding (GTAW) Manual process was used in applications such as stiffener wrap-arounds at frame penetrations, corner intersections of stiffeners and other areas where deposition of small amounts of filler material was required.

3.3.3 WELD JOINT FIT-UP AND FIXTURES -- The plates for the welded plate assemblies were machine welded using the Pacer™ accessory unit. The plates were positioned on a standard welding table, aligned to meet the specific drawing requirements, and clamped securely with dogs and strongbacks. Anodized aluminum backing bars or ceramic tile backing tapes were used for joints made from one side only. For panels with joints welded from both sides, the plates were fitted and clamped in a similar manner; however, the backing material was not used. After welding the first side, the assembly was turned over, the joint back-gouged to clean metal with a grooving cutter, and the second side was welded.

Plates comprising the larger assemblies were butt welded using the automatic welding equipment. Single side (one pass) and two side welded joints were made as described above. After the butt welds were made, these plates were moved to the general purpose weld platens and clamped down using dogs and strongbacks in preparation for installation of the stiffeners. The stiffeners were clamped using positioning blocks and fillet welded with the Wiggler™ accessory unit. Stiffener butt joints were made with semi-automatic welding equipment.

The welded assemblies for the fillet weld test specimens (TT802018) were welded in a fixture which clamped the workpieces in the specified orientation and accommodated the use of run-on and run-off tabs. These joints were welded with the Wiggler™ accessory unit.

3.3.4 WELD CONTOUR -- Weld reinforcements on certain of the assemblies required treatment to provide test specimens intended to evaluate variations in weld contour. For the assemblies which required reinforcement fairing or blending, the process was accomplished with a small disc sander. In this operation the height of weld reinforcement was not changed; only the contour was modified to remove discontinuities and steps and to provide a smooth transition from weld edge to parent metal. For most of the assemblies which required reinforcement removal, a pneumatic shaving tool was used. This device milled the reinforcement to a flat contour that was a maximum of 0.030 inch above the base metal surface. On these assemblies, no special efforts were made to blend the edge of the milled reinforcements to the parent metal. For some of the earliest produced welded plate assemblies which required reinforcement removal, a large disc sander was used to remove the reinforcement completely flush to the base metal.

3.3.5 WELD INSPECTIONS -- Visual and radiographic inspections were performed on all welds and welded assemblies in accordance with the procedures and acceptance standards planned for use on the 3KSES except that 100 percent inspection was specified for all of the structural test assemblies. Discrepancy reports were prepared for all detected conditions which were not in conformance to the applicable requirements, and required corrective action was performed.

3.3.6 WELD REPAIRS -- Two categories of weld repairs were performed during fabrication of the structural test assemblies. In the first category, repairs were required to restore defective welds to acceptable conditions. In the second category, intentional repairs were made to provide specimens with single or multiple repairs as required by the assembly drawing. More realistic representation of production conditions was provided in the latter category by the introduction of actual defects as described in paragraph 3.3.7 below.

All weld repairs were accomplished by gouging or rotary filing to completely remove the defect and rewelding using the original weld procedure parameters. Where possible, run-on and run-off tabs were used at the ends of the repaired area to prevent the introduction of weld starts and stops in the middle of the joint.

3.3.7 POST-WELD PROCESSING -- In addition to the weld reinforcement contouring and shaving described above, post-weld processing included peening of the welds on a prescribed number of assemblies to provide specimens for evaluation of this process on weld fatigue strength. Two methods of peening, air blast shot peening and rotary brush peening, were initially employed on separate groups of plate weldments for fatigue coupon specimens to determine the most effective peening method.

"As welded" assemblies were shot peened to an Almen A intensit of .004 to .008 in accordance with MIL-S-13165B, Reference 10, using the conventional air blast method with cast steel shot followed by No. 8 glass beads. No blending or smoothing of the weld reinforcements on these specimens was performed since the shot peening process was able to provide complete coverage of all reinforcement surfaces, crevices and sharp corners.

Weldments on which brush peening was to be performed first required rather extensive and time consuming blending and smoothing of the weld reinforcements to permit full coverage of all surfaces by the rotating peening wheel. Two brush peening methods were employed on the various test assemblies. The first method used an 8 inch diameter, 1 inch wide rotary brush consisting of steel shot bonded to flexible fabrous plastic flaps, which in turn were mounted to a rigid shaft-mounted hub. This brush was driven by a variable speed, high torque air motor at 3000 RPM, which produced the specified peening intensity of .004 to .008 Almen A under the load provided by 3/8 inch flap deflection. A photograph of this wheel in the operation of peening a butt weld is shown in Figure 3.3.

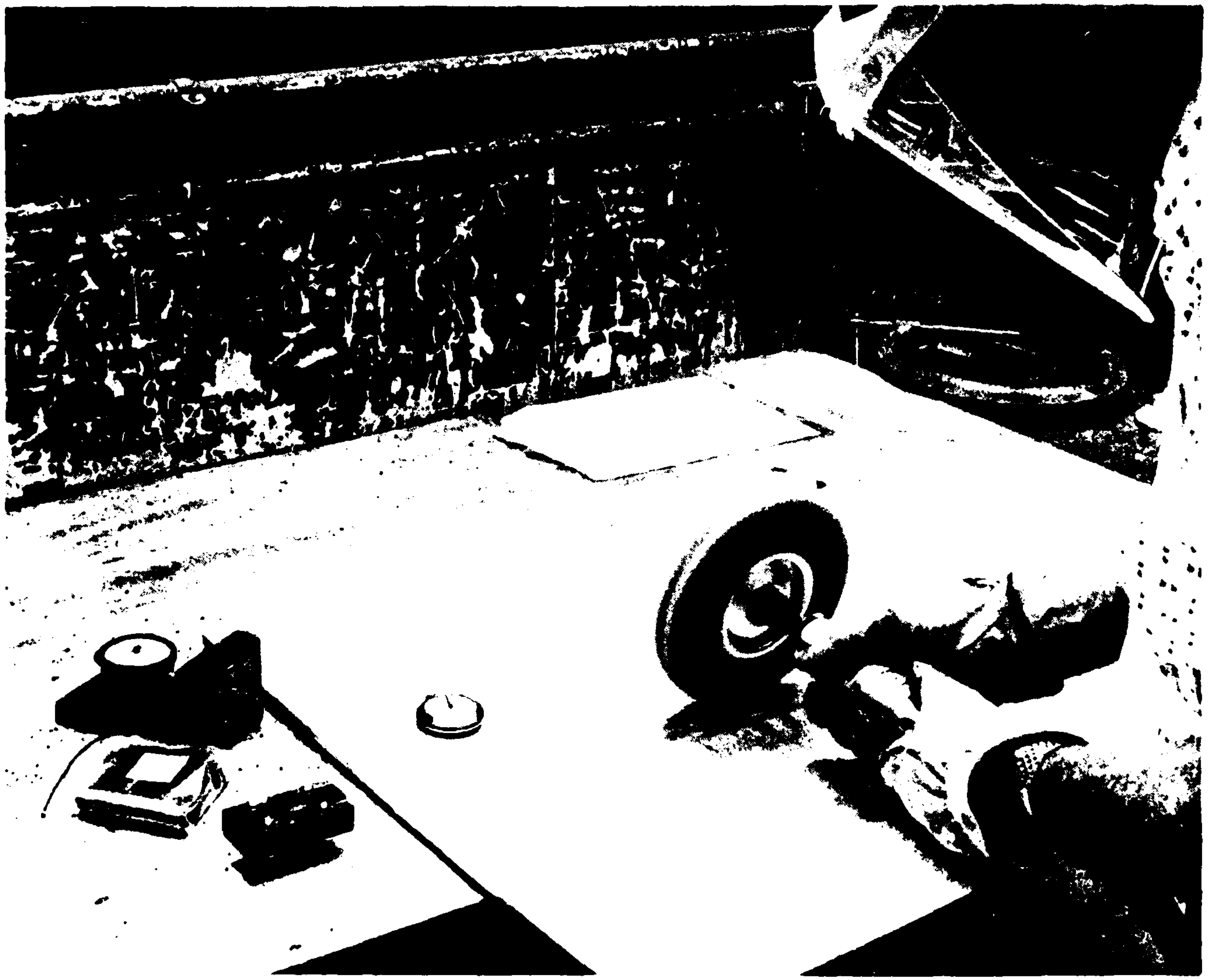


Figure 3-3. (780451-1) Rotary Brush Peening of Butt Weld

The Almen calibration strip holder and measurement gage are also illustrated in this figure. (An attempt to use a 12" diameter brush proved unsuccessful because the available motor power was insufficient to provide the required speed and flap deflection.) The second brush peening method was employed where limited access prohibited the use of the 8 inch diameter wheel. In those cases, a small flap assembly was used which consisted of a polymeric flap with tungsten carbide shot bonded to the working surfaces at each end. This flap was 9/16 inch wide by 1-1/4 inches in length and was retained at the center by a 1/4 inch diameter mandrel. This assembly was driven by a high speed air motor with a maximum speed rating of 9000 RPM.

The initial shot and brush-peened assemblies were made into specimens and tested in tension fatigue. The test results (described in detail in Section 4) indicated the brush peening process provided fatigue strength enhancement superior to that provided by the shot peening method.

Peening of all specified stiffened panel assemblies for fatigue test specimens was accomplished using the rotary brush and rotary flap processes. The use of the small rotary flap was limited to those areas, i.e., short fillets and fillet/butt weld intersections, where accessibility prohibited the use of the 8 inch diameter brush. As anticipated, acceptable peening with the small flap assembly required considerably more time than with the rotary brush for an equivalent area of coverage.

3.3.8 WELD IMPERFECTIONS -- Weld imperfections were introduced into those test assemblies prepared for evaluation of the effect of single and multiple weld repairs. Actual, rather than simulated, defects were considered necessary in order to provide realistic repair and test data. The use of specimens of opportunity, i.e., weld qualification trial samples with actual defects, was considered for the required plate weldments; however, past experience indicated this to be an

unreliable source of test specimens. Specific defects introduced into the test assemblies were excessive porosity, lack of fusion, lack of penetration and burn-through. Although the procedures used to introduce these imperfections are not specifically relevant to this report, they are of interest to aluminum welding technology and are described below for record purposes.

3.3.8.1 Porosity — Entrapped hydrogen gas is the primary cause of porosity in aluminum weldments. Aluminum in the molten state can hold 19 times more hydrogen in solution than it can after solidification. Consequently, on freezing, if the weld puddle contains hydrogen gas, this gas is rejected from solution during solidification. It is trapped in the weld because of the high solidication rate characteristic of Gas Metal Arc Welding.

Various hydrogen bearing contaminants were used in preliminary efforts to produce porosity as follows:

a. Wetting the weld surfaces with water.
b. Addition of hydrogen to the shielding gas.
c. Application of hydrated aluminum oxide to the weld surfaces.
d. Application of petroleum products to the weld surfaces.

Direct contamination of the shielding gas with water vapor was initially considered but was rejected bacause of possible damage to the welding equipment. Direct application of water to the weld surfaces was therefore attempted. This method failed because the water boiled off and was blown away by the shielding gas before the aluminum melted. Subsequent efforts involved the addition of small amounts of hydrogen to the shielding gas. Mixtures containing 0.5% and 0.012% (minimum) hydrogen by volume were used. The 0.5% mixture produced porosity considerably in excess of requirements. The reduced mixture (.012%) resulted in a weld reinforcement with noticeable peaks, and the porosity appeared to be concentrated in the toe of the weld rather than in the fit up area.

The third method consisted of the application of hydrated aluminum oxide to the weld surfaces. The hydrated aluminum oxide was prepared by mixing solutions of aluminum nitrate and ammonium hydroxide and vacuum filtering and water washing the resulting precipitate. The final product, hydrated aluminum oxide, was applied directly to the joint and, when welded, produced porosity of a distributed "frothy" nature. The porosity distribution in some cases was so fine that radiographs appeared acceptable to the naked eye; however, a large amount of very fine microporosity was distributed throughout the weld. The introduction of petroleum products to the weld surfaces proved to be a satisfactory method of producing porosity. Kerosene, greast (Lubriplate), and a hypoid gearbox lubricant (SAE90) were used. The grease and lubricant were used on fillet and butt welds, respectively, and produced porosity of a type considered acceptable for test requirements.

3.3.8.2 Lack of Pentration/Lack of Fushion -- The drawing requirements specifying lack of penetration or fushion imperfections to be of very short length and regularly spaced precluded attempts to achieve this defect by the normal mechanisms of imperfectionx. Varying the joint fitup produced extremely long defects which were considered to be unsatisfactory for testing. An attempt was made to vary the welding parameters while making the butt welds, but there was no method available that would reliably ensure short repeatable defects. Defects acceptable for the test requirements were successfully produced in some of the earlier welded test specimen assemblies by using a constant current power supply and momentarily increasing the arc length at prescribed weld travel intervals. This procedure was accomplished on the automatic welding equipment with the use of a torch height interrupter. The equipment used for this approach was not available for the later produced assemblies. As a consequence, efforts were made to simulate lack of penetration or fusion imperfections on these assemblies, but these were subsequently proved invalid during testing.

3.3.8.3 Burn-through -- The need for a burn-through type of defect in the fillet weld test program was initiated as a result of a defect found during the SES100A conversion program. It occurred during the semi-automatic welding of a stiffener to a bulkhead, when the welder momentarily paused while making the fillet weld. The required burn-through test specimens were produced with the use of the Wiggler™, a machine welder whose travel speed is controlled by its drive motor. At the specified point during a fillet weld pass, the drive wheels were momentarily lifted free of the work, thereby stopping its travel along the joint, and burn-through was achieved.

3.3.9 STRAIGHTENING METHODS -- As a result of weld shrinkage, almost all of the welded panels exhibited one form or another of distortion. The fillet welded transverse cruciform and transverse tee plate assemblies exhibited the least amounts of distortion and normally did not require straightening. The plate butt welded assemblies exhibited a moderate amount of bow which could be flattened with simple light pressure. The stiffened panels exhibited moderate to severe deformations after welding that could not be flattened by the application of pressure. A method of straightening using weld metal deposites in "X" shaped patterns was developed to restore these panels to drawing tolerance dimensions. The most effective use of this method involved clamping or otherwise restraining the panels in a flat position and, working from the center outwards, depositing weld beads in an "X" shaped pattern to shrink the excess aluminum that was visible when the panel was clamped flat. The effectiveness of this method is depicted in Figures 3-4 and 3-5 which illustrate a typical assembly before and after this straightening operation.

3.3.10 RIVETED DOUBLER INSTALLATIONS -- Doublers were installed on designated stiffened panel assemblies for evaluation of this design first, as a sole means of butt joining flatbar stiffeners, and second, as a means of improving the fatigue performance of repair welded butt joints. Blind rivets (Huck type OSR-10) were used to install the

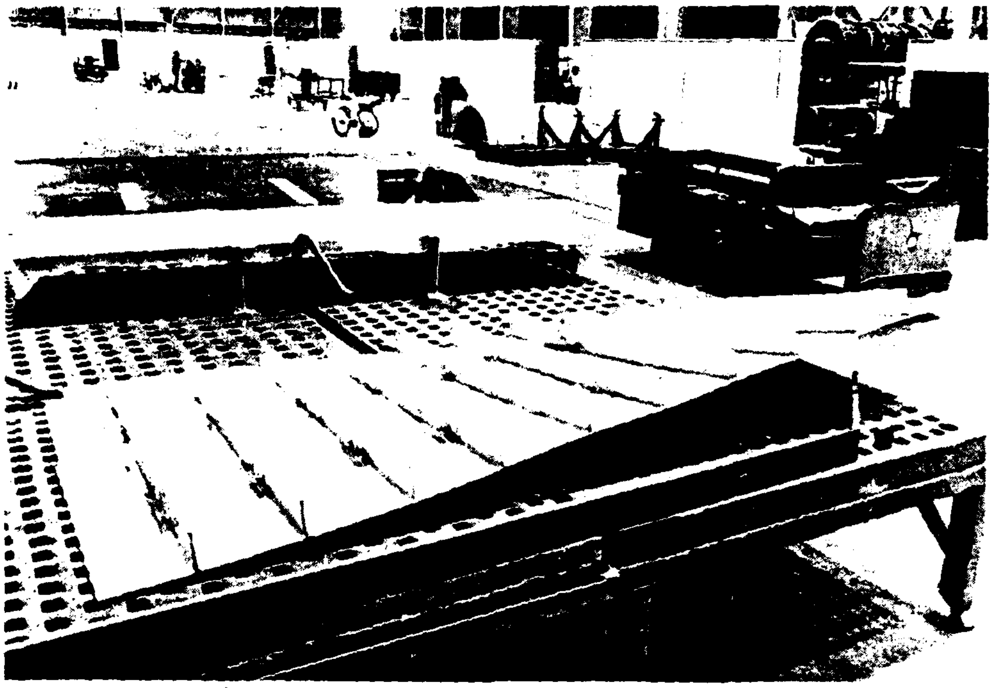


Figure 3-4. (780451-6) Typical As-Welded Distortion of Stiffened Panel Assembly.

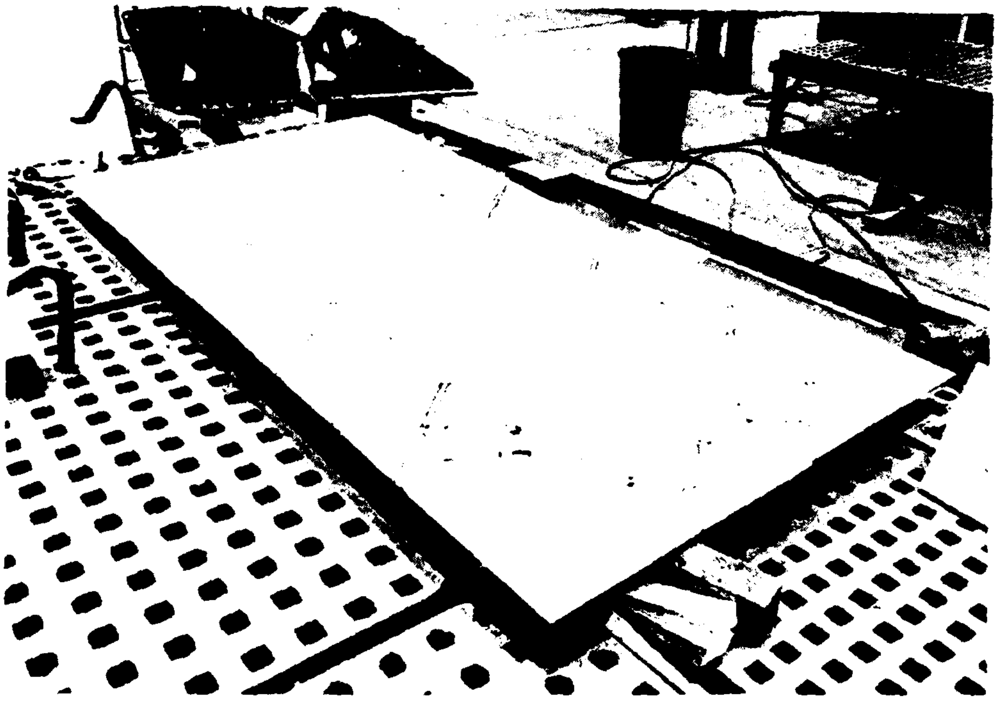


Figure 3-5. (780451-12) Stiffened Panel Assembly After Surface Shrink-Weld Straightening

doublers on the stiffener unwelded butt joints and on the repaired butt joint welds. This type of rivet was selected primarily for its relative ease of installation in a potential shipboard repair application and its hole-filling ability. A pneumatic rivet puller was used to install the blink rivets in match drilled and reamed holes. Prior to installation of doublers over the repair welded butt joints, the reinforcements were ground flush to provide intimate contact of the faying surfaces.

3.3.11 BONDED DOUBLER INSTALLATIONS -- Bonded doublers were installed on the designated stiffened panel assemblies using the cleaning and bonding procedures contained in Appendix B. These procedures were designed to provide a method suitable for use as an in-service repair by operating personnel. The detailed procedures in Appendix B were written for two adhesive systems, Hysol types EA9309.1 and EA9314, to acquire comparative data. The EA9309.1 adhesive was very "slick". Both adhesives were judged relatively easy to use, and both performed well during testing.

3.4 DISCREPANCIES AND DEVIATIONS

In the production of the various assemblies and test panels, a number of unplanned discrepancies were inevitably introduced beyond the intentionally produced imperfections. Where such unplanned discrepancies were located outside the area of the actual test coupons or specimens, they were identified as such and accepted for use. In some cases where the repair of a weld discrepancy could result in an unacceptable test assembly, the panel was cut apart at the joint and rewelded to the drawing requirements.

Various designated stiffened panel assemblies for structural testing required peening of welds in specific areas. In the performance of this operation, welds in other areas were inadvertently peened. The fabrication of replacement assemblies with the specified peen/lack of peen areas would have adversely affected the program schedule and cost. Therefore, a method was developed to remove the effects of the unwanted peening.

A literature search and discussions with knowledgeable personnel failed to disclose any appropriate method, process, or technique that would remove the effect of peening without compromising the integrity of the weld. Grinding the surface would result in an unacceptable reduction of weld material and excessive removal of parent material. Deposition of additional weld metal would excessively reinforce the joint. Therefore, a thermal technique was selected to "unpeen" the erroneously peened weld areas. This was accomplished with Gax Tungsten Arc Welding Alternating Current equipment using a low setting in a "wash pass" mode (with no filler wire) on the discrepant welds. The arc was very carefully moved along the affected areas with close observations of the heated zone. Since aluminum exhibits no color change when heated to its melting point, and temperature indicating markings would contaminate the weld areas, visual observation of the peened area was employed to stop heating just as the weld surface became molten and shiny. This effectively annealed and relieved the compressive stresses on the surface of the peened joint areas.

A common occurrence on welds made from one side against removable backing was rollover of the root reinforcement of the toe resulting in re-entrant toe angles. This effect was caused by a combination of chilling of the weld bead, insufficient shielding gas, and incomplete "wetting" of the parent metal by the weld head. Normally this condition was detected by the welder and/or the inspector, andthe discrepant condition removed by the use of sanding discs. However, several stiffened panels with toe re-entrant angles on the root reinforcements were inadvertently accepted for use as specimens which adversely affected the fatigue test results as described in Section 5 of this report.

Cognizant production and inspection personnel were advised whenever significant, but previously undetected, discrepancies were pinpointed during the course of testing. In this manner, recognition and evaluation of the need for possible corrective action to minimize future occurrences during 3KSES production were initiated.

4 / WELDED PLATE COUPON TESTS

4.1 GENERAL

Testing of simple welded sheet and plate specimens containing various configurations of transverse butt and fillet welds constituted the initial phase of panel tests under the Panel and Element Structural Test Program. These tests were conducted in accordance with Test Plan TPP00016A, Reference 1, except for minor deviations explained herein.

Based on economic considerations, the welded plate coupon tests served as the principal means of evaluating basic fabrication and geometric parameters. As such, coupons were fabricated and tested to evaluate butt welds made from one side and from both sides; with the weld reinforcement intact, removed, or blended; with the joints offset mismatched or angularly misaligned; with various equal and differential material thicknesses; with shot peening and rotary brush peening; with deliberate weld imperfections; and with weld repairs. Fillet weld parameters evaluated included joint configuration, material thickness, reinforcement contour, penetration depth, weld repairs and brush peening.

All of the individual welded plate coupon speciments were sections as replicates from larger plate assemblies specially fabricated for the purpose. All of the larger panels were subjected to visual and radio-

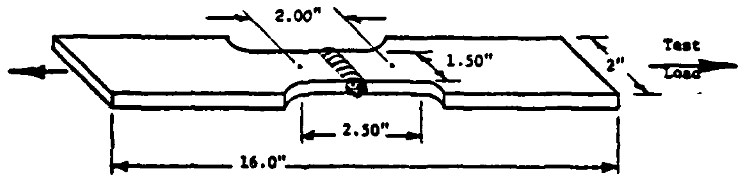
graph inspections and, except for the specified deviations, were attested by Quality Assurance to be in conformance with proposed 3KSES acceptance standards for production welds, dimensional tolerances and fairness standards.

Altogether a total of 266 butt welded plate specimens and 55 fillet welded plate specimens were tested in this phase of the Panel and Element Structural Test Program. Testing encompassed static tension, tensile fatigue and bending fatigue as described in detail below.

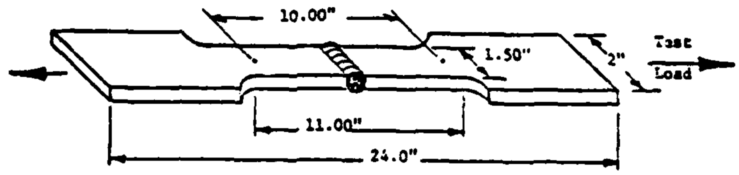
4.2 SPECIMEN DESCRIPTION

4.2.1 BUTT WELD SPECIMENS -- The basic test specimen configurations employed for the butt welded plate coupon static tension, tensile fatigue and bending fatigue tests are illustrated in Figure 4-1. Most of the static tensile test specimens were made to eh 2-inch gage length configuration per Figure 4-1(a), with the remainder made to the 10-inch gage length configuration per Figure 4-1(b). The 2-inch gage length configuration conformed to the requirements of FED-STD-151a, Type F1 (Reference 11) and MIL-STD-418C (Reference 12) except for those specimens with retained weld reinforcement. The 10-inch gage length specimens provided data directly correlatable to existing H-5 Test Program and Aluminum Association 10-inch gage length strength data. Although MIL-STD-418C requires that the weld reinforcement be removed blush with the surface of the specimen, the specimens in this program were tested both with reinforcement-removed and reinforcement-intact weld geometries. This approach was in keeping with the validation of production joints and not qualification of the welds.

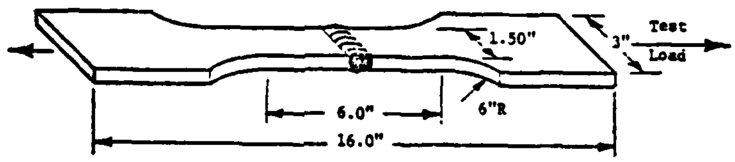
The basic configuration for the axial fatigue specimens as shown in Figure 4-1(c), was in conformance with the requirements of ASTM-E466 (Reference 13) for specimens with tangentially blending radii between a uniform width test section and the ends except that the radii were reduced to 6-inches to facilitate machining. The effect of the smaller radii was negligible on these welded uniform test section specimens.



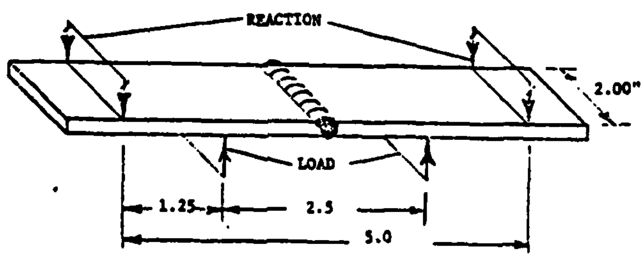
a) Static Tensile Test Coupon - 2-inch Gage Length



b) Static Tensile Test Coupon - 10-inch Gage Length



c) Axial Fatigue Test Coupon



d) Bending Fatigue Test Coupon

Figure 4-1. Butt Welded Plate Test Specimen Configurations

Bending fatigue specimens were designed for testing as a simple beam with symmetrical two point loading producing a uniform bending moment between the load points. Since no recognized standard existed to define the basic geometry of this type of specimen, the geometry shown in Figure 4-1(d) was selected to achieve the desired stress level within the capability of standard fatigue test machines and setups.

Descriptions of the various joint parameters and the combinations incorporated in each butt weld static and fatigue test specimen are contained in Tables 4-1 through 4-3.

Photographs of typical specimen profiles fabricated with intentional joint offset mismatch and joint angular misalignment are shown in Figures 4-2 and 4-3.

4.2.2 BUTT WELD IMPERFECTION SPECIMENS -- A special group of axial tension static and fatigue specimens, as described in Table 4-4, were fabricated from weld assemblies with weld imperfections purposely incorporated. Specimen coupons were located, as shown typically in Figure 4-4, based on assembly radiographs. Detail views of the welds on typical specimens contain excessive porosity are shown in Figure 4-5.

As noted in Section 3 of this report, extreme difficulties were encountered in producing weld assemblies of the required porosity densities and lack of fusion/penetration levels. Consequently, it was necessary to deviate from the Reference 1 test plan by redistributing porosity specimen quantities based on obtainable densities, and reducing the scope and quantities of the lack of fusion/penetration specimens. The porosity levels and corresponding specimen quanties shown in Table 4-4 reflect the obtained porosity density distributions and original test plan objectives. However, all of the lack of fushion/penetration levels shown in Table 4-4 exceed the limits of the original test plan objectives.

Table 4-1. Welded Plate Axial Tension Test Specimens, Butt Joints Welded Single Pass from One Side.

TEST: STATIC Specimen Drawing Number △2	7" Gage Lgth	10" Gage Lgth	Quantity	TEST: FATIGUE Specimen Drawing Number △2	Quantity	Weld Bead Geometry: Reinforcement Intact	Weld Bead Geometry: Reinforcement Removed	Joint Fit-Up: Nominal	Joint Fit-Up: Mismatch	Joint Fit-Up: Misalign	Weld Condition: As Welded	Weld Condition: Single Repair	Weld Condition: Multiple Repairs	Post Weld Processing: Rotary Flapper Peened	Post Weld Processing: Shot Peened	Post Weld Processing: △3 Optimum Peened	Post Weld Processing: Reinforcement Faired	Post Weld Processing: Faired and Peened	Thickness of Joined Parts: .160 - .160	Thickness of Joined Parts: .190 - .313 △1	Thickness of Joined Parts: .313 - .313	Plate △2 Weldment Drawing Number
				TT802019-1	3	X		X			X								X			TT802015-1
				-7	3	X			X		X								X			-11
TT802016-21	X	X	3	-3	3	X		X			X										X	-301
-7	X		2	-9	3	X			X		X										X	-333/-315(static)
-3	X		2	-5	3	X		X			X									X		-101
TT802016-9	X		2	-15	3	X			X		X									X		-113/-115(static)
				-21	3	X				X	X									X		-119
				-11	3	X		X			X			X							X	-305
				-13	3	X		X			X			X						X		-103
				-17	3	X		X			X				X						X	-307
				-19	3	X		X			X				X					X		-105
				-25	3	X		X			X						X			X		-107
				-31	3	X		X			X							X		X		-109
				-23	3	X		X				X							X			-5
				-33	3	X		X				X		X					X			-15
				-27	3	X		X				X			X				X			-9
				-29	3	X		X				X									X	-309
				-37	3	X		X				X		X							X	-325
				-35	3	X		X				X			X						X	-329
				-43	3	X		X					X								X	-311
				-39	3	X		X					X			X					X	-327
				-51	3	X		X					X				X				X	-331
				-45	3	X		X				X								X		-111
				-41	3	X		X				X				X				X		-127
				-65	3		X	X			X								X			-3
TT802016-53	X	X	3	-67	3		X	X			X										X	-303
				-75	3		X	X			X					X					X	-313
				-47	3		X	X				X							X			-7
TT802016-43	X		2	-49	3		X	X				X									X	-321/-323(static)
				-83	3		X	X				X				X					X	-337
				TT802019-85	3		X	X					X			X					X	-339
TT802016-25	X		2				X		X		X										X	-317
-27	X		2				X		X		X									X		-117
-33	X		2				X			X	X										X	-319
TT802016-47	X		2				X		X			X									X	TT802015-343
TOTAL			22		93														21	33	61	

△1 Welded from stepped side.

△2 Reference Appendix A

△3 Optimum method proved to be rotary flapper peening based on comparative tests.

Table 4-2. Welded Plate Bending Fatigue Test Specimens, Butt Joints Welded Single Pass from One Side.

Specimen (4) Drawing Number	Joint Fit-Up	Weld Reinforcement Geometry		Weld Condition		Post Weld Processing			Bending Direction		Thickness of Joined Parts			Plate (4) Weldment Drawing Number
	Nominal	Reinforcement Intact	Reinforcement Removed	As Welded	Single Repair (1)	Rotary Flapper Peened	Shot Peened	(5) Optimum Peened	Weld Crown Tension	Weld Root Tension	.190 (2) .313	.313 - .313	Quantity	
TT802020-15	X	X		X						X	X		3	TT802015-121
-1	X	X		X					X			X	3	-301
-1	X	X		X						X		X	3	-301
-3	X	X		X			X		X			X	3	-307
-3	X	X		X			X			X		X	3	-307
-5	X	X			X	X				X		X	3	-325
-9	X		X	X						X		X	3	-303
-11	X		X	X				X		X		X	3	-313
-13	X		X		X			X		X		X	3	-337
TT802020-101 (3)	X	X	X	X					X			X	3	TT802015-401
Totals													30	

(1) Repaired from weld root side

(2) Welded from stepped side.

(3) Butt joint welded from both sides

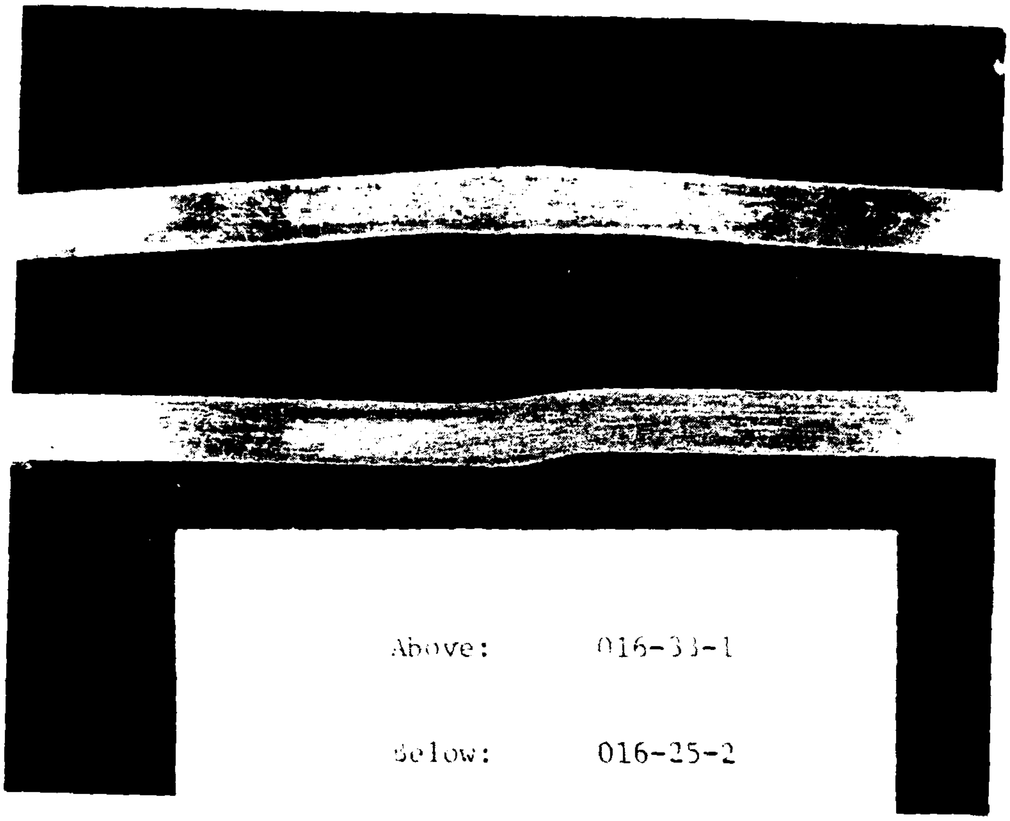
(4) Reference Appendix A

(5) Optimum method proved to be rotary flapper peening.

Table 4-3. Welded Plate Axial Tension Test Specimens, Butt Joints Welded from Both Sides.

TEST						Weld Reinforcement Geometry		Post Weld Processing		Joint Fit-Up		Thickness of Joined Parts			Plate ⚠
STATIC				FATIGUE											
⚠ SPECIMEN DRAWING NUMBER	2" Gage Length	10" Gage Length	Quantity	SPECIMEN ⚠ DRAWING NUMBER	Quantity	Reinforcement Intact	Reinforcement Removed	Rotary Flapper Peened	Reinforcement Faired & Peen.	Nominal	Mismatch	.313 - .313	.375 - .500	.750 - .750	Weldment Drawing Number
TT802016-119	X	X	2	TT802019-101	3	X				X		X			TT802015-401
				-103	3	X				X				X	-701
				-105	3	X				X			X		-501
				-109	3	X		X		X		X			-405
				-111	3	X		X		X				X	-705
				-113	3	X		X		X			X		- 505
				-115	3	X			X	X		X			-407
TT802016-135		X	3	TT802019-121	3		X			X		X			-403
-123	X		2				X				X	X			-411
TT802016 -127	X		2				X				X		X		TT802015-509
TOTALS			9		27							22	8	6	

⚠ Reference Appendix A



REMOVE THIS TARGET!

Figure 4-2. (78-608-4) Weld Joint Geometries for Angular Misalignment (above) and Offset Mismatch (below) with Weld Reinforcements Removed.

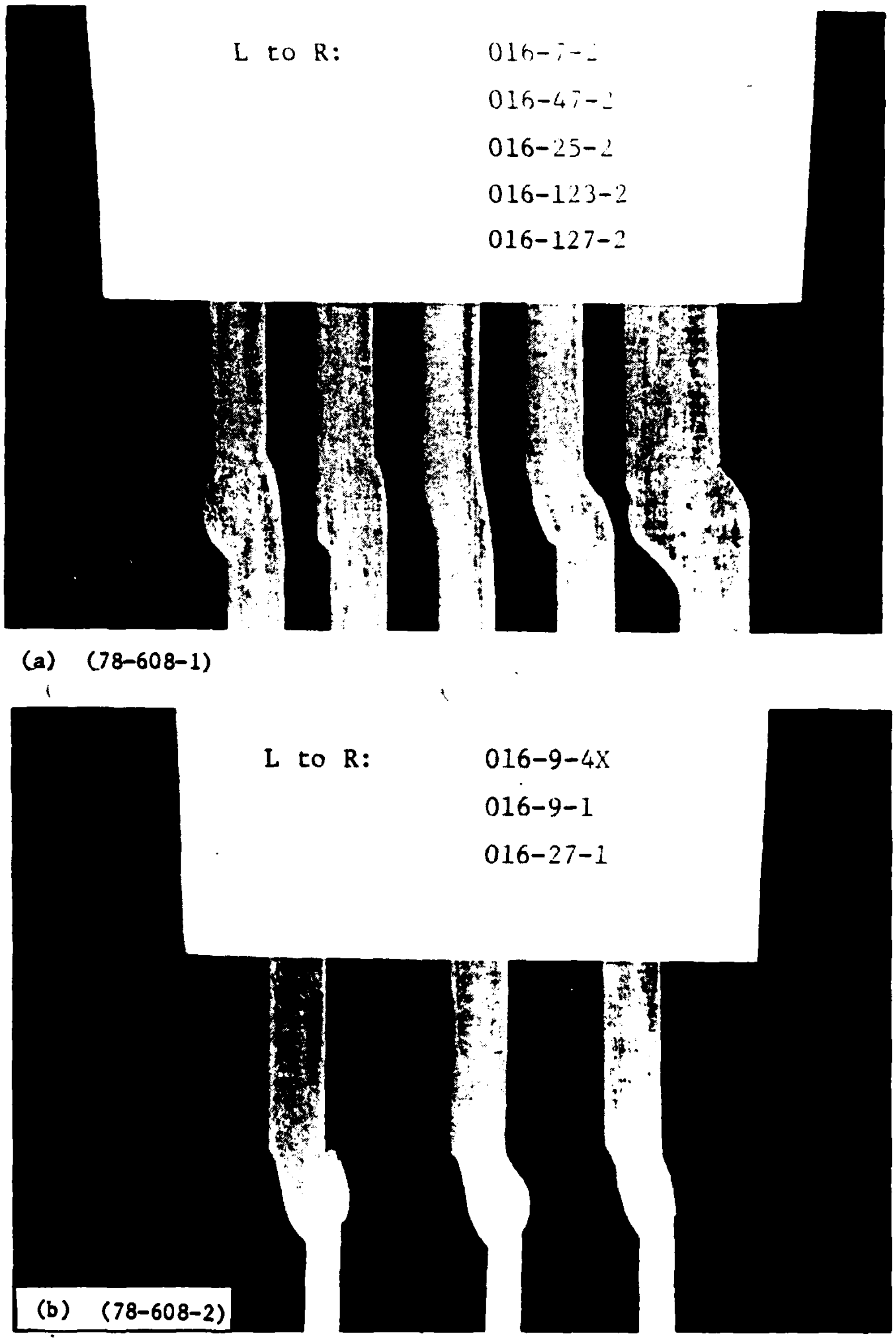


Figure 4-3. Typical Variations in Weld Joint Geometries for Specimens with Offset Mismatch.

Table 4-4. Welded Plate Axial Tension Test Specimens, Butt Joints Welded Single Pass from One Side with Weld Imperfections.

Specimen Drawing Number △	Test Type: Static △	Test Type: Fatigue	Weld Reinf Geometry: Reinforcement Intact	Weld Reinf Geometry: Reinforcement Removed	Thickness of Joined Parts: .190 - .190	Thickness of Joined Parts: .375 - .375	Type of Imperfection: Porosity	Type of Imperfection: Lack of Fusion/ Penetration	Imperfection Level, Porosity: <2.35%	Porosity: 2.35 to 5%	Porosity: 5.01 to 7.5%	Porosity: >7.5%	LOF: <1/8"	LOF: 1/8" to 1/4"	Surface Cracks	Total Quantity	Plate Weldment Drawing Number △
TT802016-301	X			X	X		X			1					2	3	TT802021-1
-303	X			X	X		X					2			1	3	-3
TT802019-401		X		X	X		X		2	4		1			1	8	-1
-403		X		X	X		X			1	3	1			1	6	-3
TT802016-305	X			X	X			X					2	1		3	-5
-307	X			X	X			X					1	2		3	-7
TT802019-405		X		X	X			X					4	2		6	-5
-407		X		X	X			X					3	3		6	-7
TT802016-313	X		X		X		X				1	2				3	-13
TT802016-315	X		X		X		X				1	1				2	-15
TT802019-413		X	X		X		X			3	1					4	-13
-415		X	X		X		X		1			3				4	-15
TT802016-317	X		X		X			X					2	2		4	-17
TT802019-417		X	X		X			X						4		4	-17
TT802016-319	X			X		X	X		2							2	-101
TT802016-321	X			X		X	X			2						2	-103
TT802019-419		X		X		X	X		4	2	1					7	-101
TT802019-421		X		X		X	X		2		1	3				6	-103
TT802016-323 △	X			X		X		X									-105
TT802016-325 △	X			X		X		X									-107
TT803019-423 △		X		X		X		X									-105
TT802019-425 △		X		X		X		X									-107
TT802016-327	X		X			X	X		2							2	-109
-329	X		X			X	X			1		1				2	-111
TT802019-427		X	X			X	X		1	2	1					4	-109
-429		X	X			X	X			3		1				4	-111
TT802016-331 △	X		X			X		X									-113
TT802019-431 △		X				X		X									TT802021-113
TOTAL									14	19	9	15	12	14	5	88	

NOTE: All specimens were fabricated with nominal joint fit-up and remained in the as-welded condition.

△ Not tested since required imperfection could not be produced.

△ Two inch gage length only.

△ Reference Appendix A.

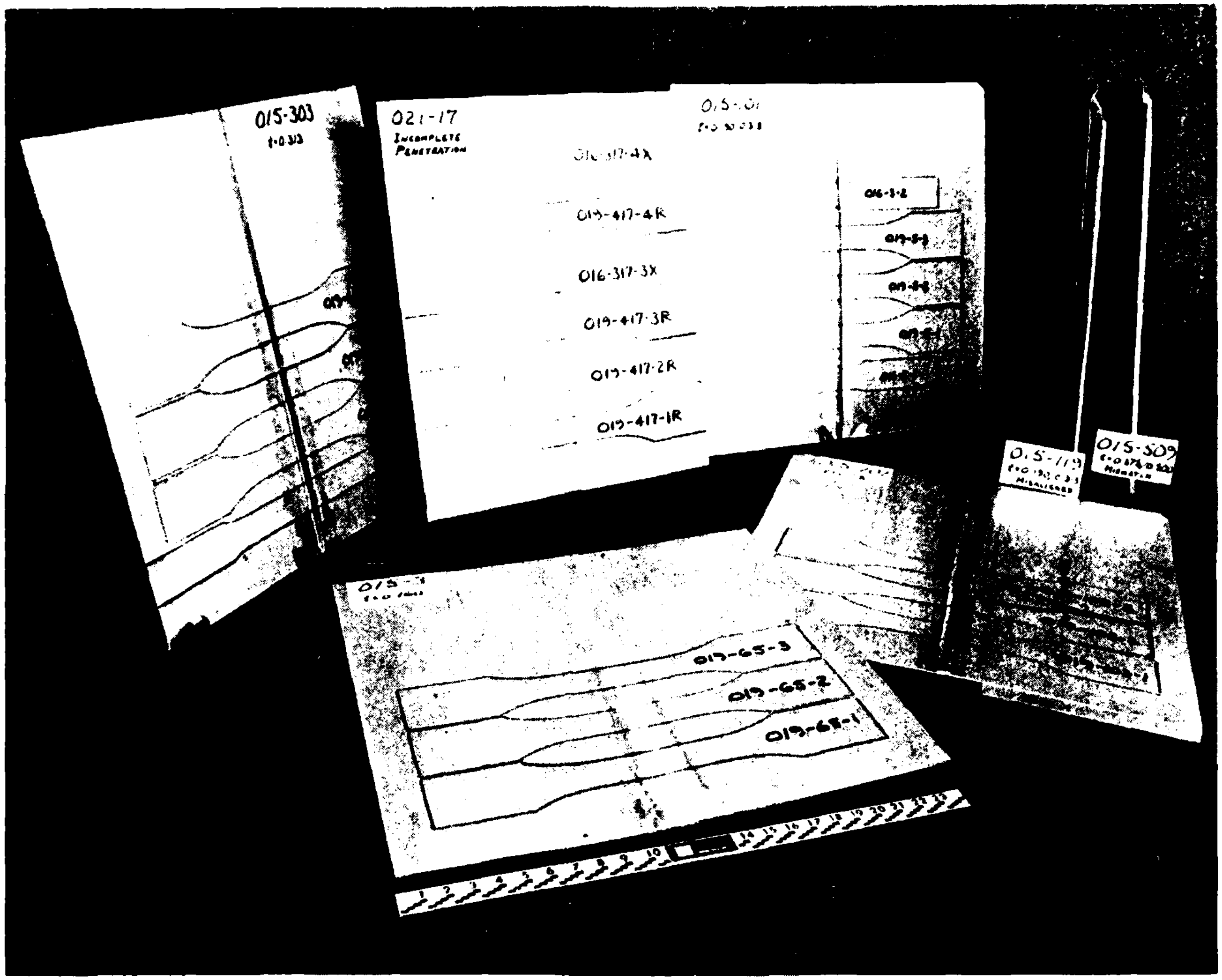
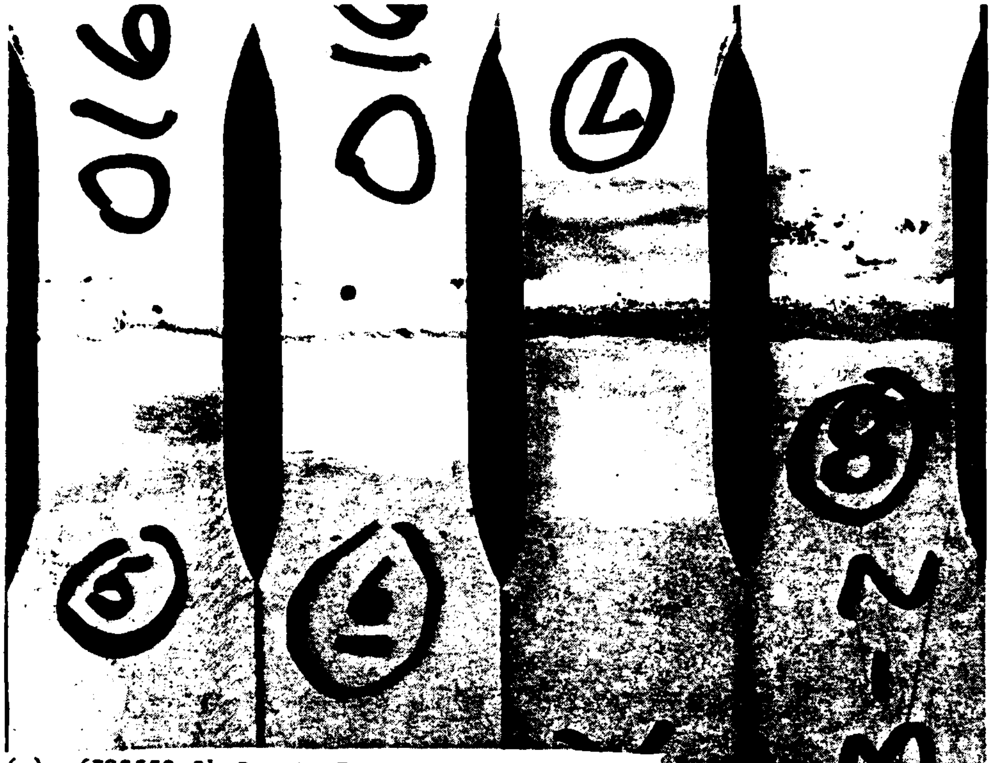


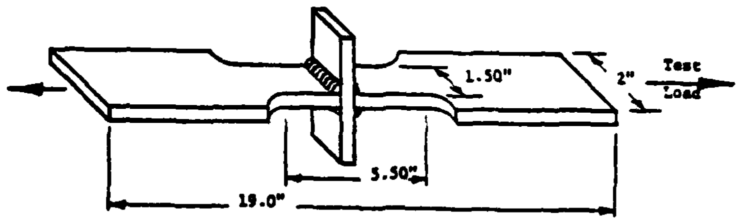
Figure 4-4. (780489-2) Typical Butt Welded Plate Fabrication Assemblies. Note markings depicting locations of tensile static and fatigue test specimens.



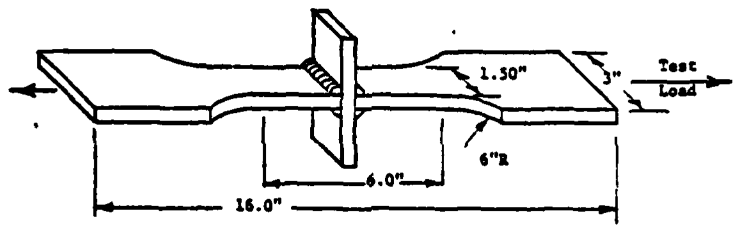
(a) (790550-5) Static Tensile Test Specimens

(b) (790550-3) Axial Fatigue Test Specimens

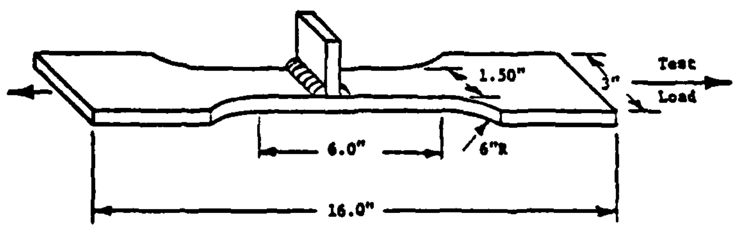
Figure 4-5. Typical Joint Surfaces on Excess Porosity Weld, Imperfection Test Specimens



a) Transverse Cruciform Static Tensile Test Coupon

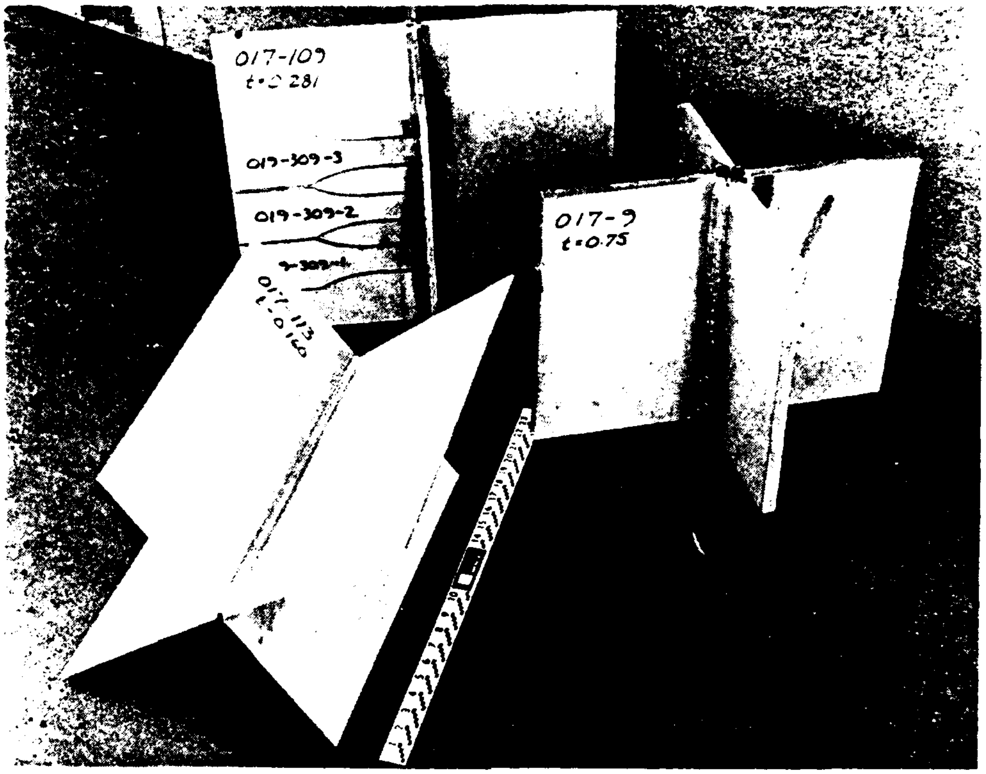


b) Transverse Cruciform Axial Fatigue Test Coupon

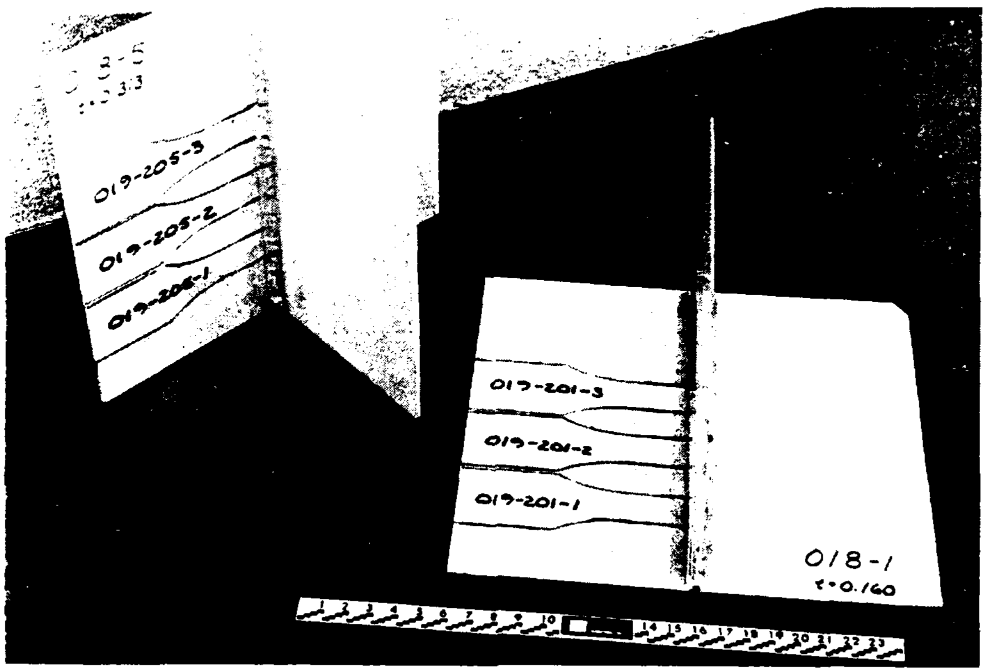


c) Transverse Tee Axial Fatigue Test Coupon

Figure 4-6. Fillet Welded Plate Test Specimen Configurations.



(a) (780489-4) Transverse Cruciform Assemblies



(b) (780489-6) Transverse Tee Assemblies

Figure 4-7. Typical Fillet Welded Plate Fabrication Assemblies with Test Specimen Locations

4.2.3 FILLET WELD SPECIMENS -- The basic test specimen configurations employed for the fillet welded plate static tension and tensile fatigue tests included both transverse cruciform and transverse tee joints as shown in Figure 4-6. These specimens were in compliance, to the extent practicable, with the standards described above in Paragraph 4.2.1 for the butt weld specimens. All of the fillet weld test specimens were cut as replicates from larger welded plate fabrication assemblies as shown in Figure 4-7.

Descriptions of the various joint parameters and combinations incorporated in each fillet weld specimen are summarized in Table 4-5.

4.3 SPECIMEN PREPARATION

4.3.1 BUTT WELD SPECIMENS -- All of the butt weld specimens were rough cut from larger assemblies and trimmed by edge milling to the final required configuration. Test grip holes were then located and drilled. The edges of all fatigue test specimens were hand polished to remove any scratches or nicks; the plate and weld reinforcement surfaces were left in the as-received condition. Strain gages were installed on selected static and fatigue test specimens as described in Paragraph 4.5 below.

Prior to test, all specimens were accurately measured to determine actual test section dimensions as indicated in Figure 4-8. The recorded dimensions for each specimen are tabulated in Appendix B. Appropriate gage length marks were scribed on the static test specimens for use in determining percentage elongation data.

4.3.2 BUTT WELD IMPERFECTION SPECIMENS -- All specimens containing excessive porosity were re-radiographed, after being cut from the larger fabrication assemblies, to determine specific porosity densities. Most of the later test specimens were also photographed to document the weld reinforcement surface condition. Remaining specimen

preparation was essentially the same as described above for the butt weld specimens.

4.3.3 FILLET WELD SPECIMENS -- Specimen preparation for the fillet weld transverse cruciform and tee specimens was essentially the same as described above in Paragraph 4.3.1 for the butt weld specimens.

4.4 TEST SETUPS AND FIXTURES

4.4.1 STATIC TENSION TESTS -- The setup employed for all of the welded plate coupon static tensile tests, except the first specimen, consisted of a 300,000 pound capacity Tinius-Olsen Universal Test Machine meeting all applicable ASTM (American Society for Testing and Materials) standards. This machine was equipped with standard serrated wedge grips and provided a test section 28 inches in width with a height variable up to 72 inches. An integral autographic recorder provided applied load versus strain curves when connected to a 2-inch or 10-inch gage length extensometer mounted on the test specimen. Accuracy of the Tinius-Olsen Test Machine was within ± one percent of full scale as established by calibration conforming to MIL-C-45662A (Reference 14) and traceable to the National Bureau of Standards.

Since the butt weld and fillet weld static tension test specimens were basically flat plate tensile tests per FED-STD-151a (Reference 11), the ends of the specimens were simply clamped in the serrated grips. Attachment and connection of the appropriate gage length extensometer(s) completed the setup. A typical welded plate coupon static tensile test setup is illustrated in Figure 4-9.

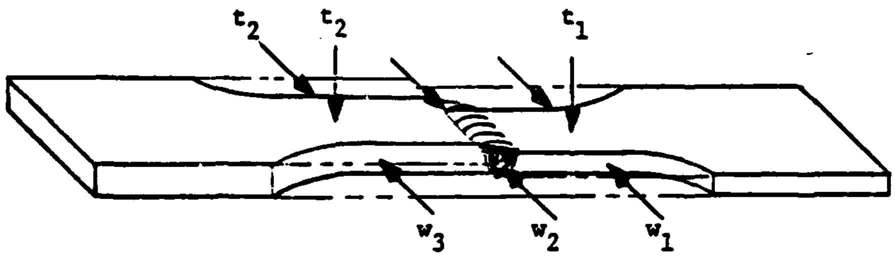
On those butt weld specimens configured with a 10-inch gage length, both 10-inch and 2-inch gage length extensometers were clamped in place, centered on the weld to obtain directly comparable data. Detail views of a typical dual extensometer installation are shown in Figure 4-10.

Table 4-5. Welded Plate Axial Tension Test Specimens, Fillet Welded.

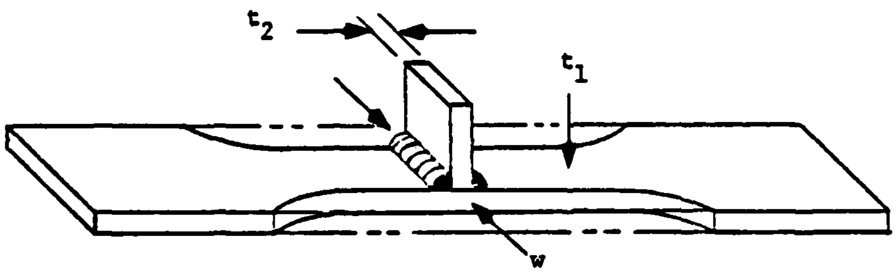
Specimen △2 Drawing Number	Test Type		Specimen Type		Weld Reinf. Geometry		Weld Type		Weld Condition		Post Weld Process		Thickness of Joined Parts			Quantity	Plate △2 Weldment Drawing Number
	Fatigue	Static	Transverse Tee	Transverse Cruciform	Concave or Flat	Convex	Fillet	Full Penetr. Groove Tee	As Welded	Repaired	None	Rotary Flap Peened	.160 - .160	.281 - .281	.313 - .313		
TT802019-201	X		X			X	X		X		X		X			3	TT802018-1
-203	X		X		X		X		X		X				X	3	-3
-205	X		X			X	X		X		X				X	3	-5
-209	X		X		X		X		X		X				X	3	-9
-211	X		X			X	X			X	X				X	3	-11
-213	X		X			X	X			X		X			X	3	-13
-221	X		X			X	X			X △1	X				X	2	-23
-223	X		X			X	X			X △1		X			X	2	TT802018-25
-301	X			X	X		X		X		X		X			3	TT802017-101
-303	X			X		X	X		X		X		X			3	-103
-305	X			X	X		X		X		X			X		3	-105
-307	X			X		X	X		X		X			X		3	-107
-309	X			X		X	X			X	X			X		3	-109
-311	X			X		X	X			X		X		X		3	-111
-313	X			X		X		X	X		X		X			3	-113
TT802019-315	X			X		X		X	X		X			X		3	-115
TT802016-201		X		X	X		X		X		X		.18-1/8"Fil.			3	-1
		X		X	X		X		X		X		.50-3/8"Fil.			3	-5
TT802016-201		X		X	X		X		X		X		.75-5/8"Fil.			3	TT802017-9
TOTAL																55	

△1 Repair of weld burn-through.

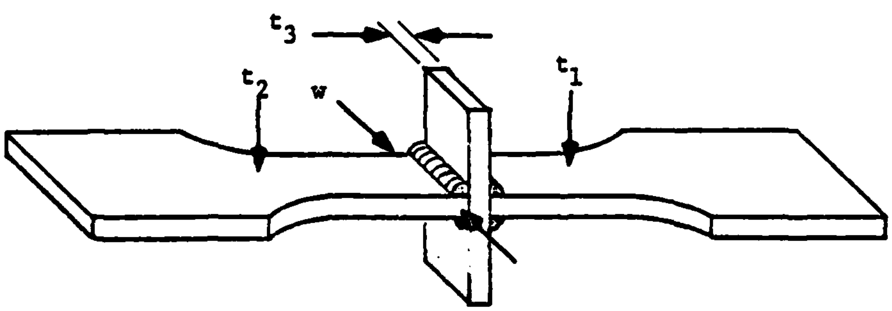
△2 Reference Appendix A.



Transverse Butt Joint Specimen



Transverse Tee Joint Specimen



Transverse Cruciform Joint Specimen

Figure 4-8. Welded Plate Specimen Pretest Measurement Locations.

The initial static tensile test coupon specimen (Serial No. 016-53-1) was setup and tested in a 50,000 pound capacity Instron Model TTK-50 Universal Testing Machine meeting all applicable ASTM Standards. The Instron Test Machine provided a test section 28 inches in width with a height variable up to 48 inches. This machine incorporated an integral servo-controlled recorder to provide load indication and load versus displacement curves. Rate of load application could be varied from 0.0005 up to 10-inches per minute of head travel. The Instron Test Machine utilized two load cells to indicate the applied loading - an integral 50,000 pound capacity load cell and an insertable 1,000 pound capacity load cell which was utilized for low load levels. Combined accuracy of the applicable load cell, selected chart gain setting, and chart recorder display was $\pm$ one percent of full scale on the chart as established by calibration conforming to MIL-C-45662A and traceable to the National Bureau of Standards.

Problems were encountered with the Instron pin-loading specimen grips during testing of the initial welded plate static tensile coupon. As a result, the Tinius-Olsen Test Machine was utilized for the remainder of the planned test program.

4.4.2 TENSILE FATIGUE TESTS — The setup for the welded plate coupon tensile fatigue tests consisted of a 15,000 pound capacity Krouse Standard Fatigue Machine which operated at 1000 cycles per minute. Since the test specimens were flat plates, standard bolted clamping grips were utilized. The required fatigue test loads were setup and maintained using the Krouse eccentrically offset calibrated load arm displacement and hydraulic load control cylinder. The test setup is shown in Figure 4-11.

4.4.3 BENDING FATIGUE TESTS — The setup for these tests consisted of a 2000 pound capacity Baldwin - Sonntag Standard Fatigue Machine (which operated at 1800 cycles per minute) utilized in conjunction with standard fixturing to provide simple supports at the

at the specimen ends and loading at the specimen quarter-span points as depicted in Figure 4-12. This fixturing, which incorporated transverse rollers at the support and load points, produced a uniform bending moment in the specimen area of investigation. The test loading was applied in an upward direction producing tensile stresses on the specimen upper surface to facilitate unrestricted observations of the failure initiation area.

4.5 INSTRUMENTATION AND DATA ACQUISITION EQUIPMENT

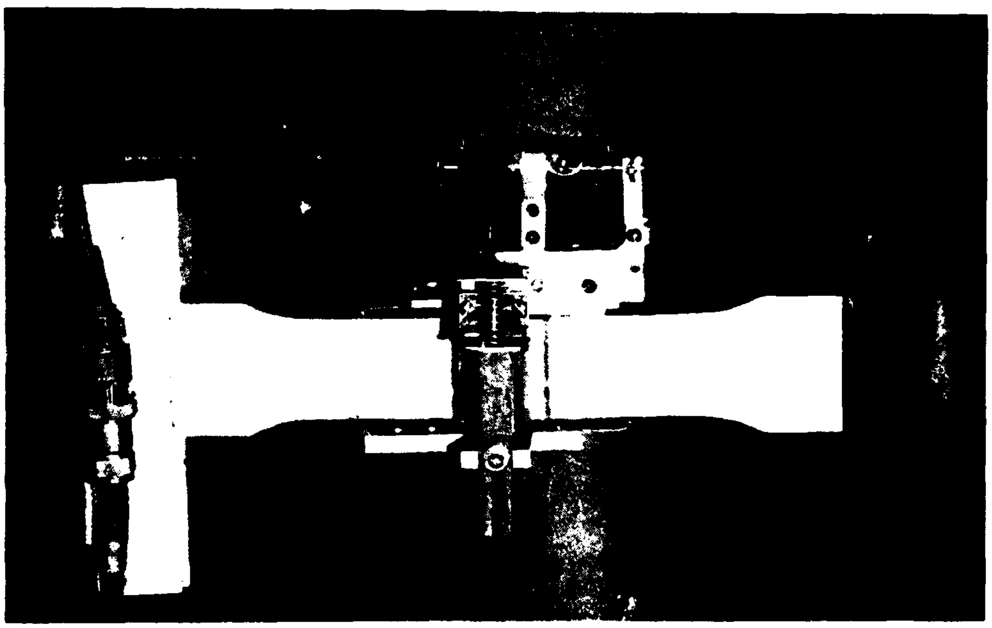
Selected mismatched and misaligned static tension specimens were strain gaged as indicated in Figure 4-13 to verify the effect of local bending on nominal strain. Strain gages were installed on the following specimens: TT802016-25-1, TT802016-27-2, TT802016-33-2, TT802016-123-1, and TT802016-127-1. In addition, one bending fatigue specimen (TT802020-9-1) was strain-gaged to verify test section stresses.

Strain gages on the static tensile specimens were read directly from a Budd Strain Indicator. The specimen extensometer reading was simultaneously autographically recorded on the Tinius-Olsen machine. When two extensometers were utilized on a single specimen, the second extensometer was connected to the recorder on the Instron Test Machine; values of the applied load were manually marked on the Instron chart.

Individual Instrumentation items utilized during testing are listed below:

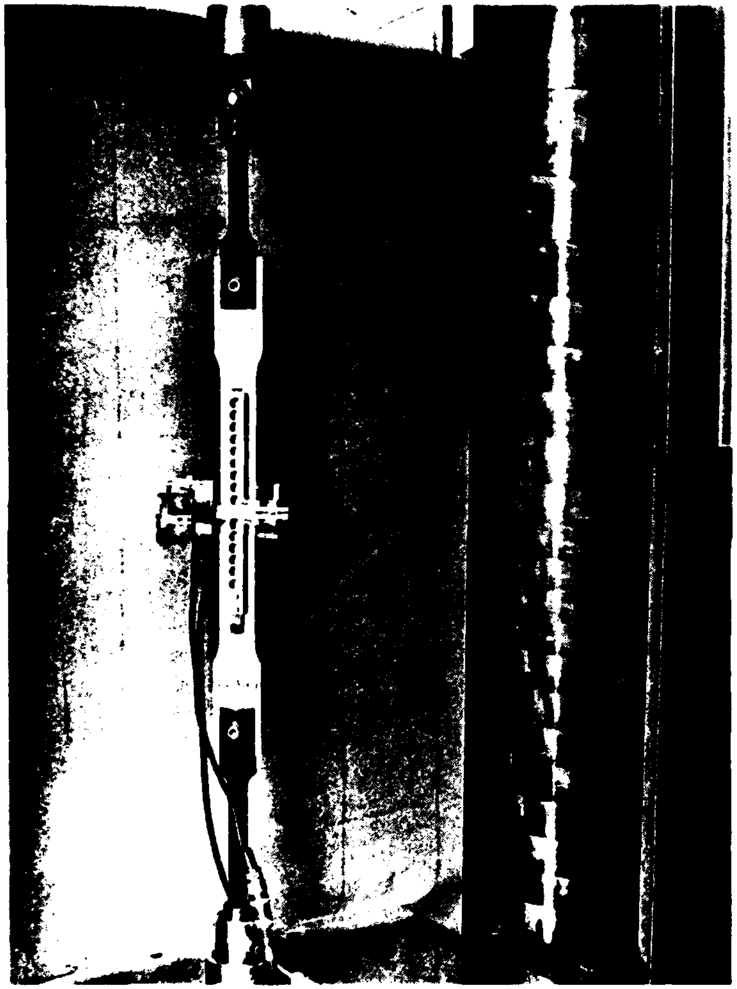
ITEM	MANUFACTURER	DESCRIPTIONS
Strain Gage	Micro-Measurements Incorporated	EA-13-205BG-120 Static Range: ± 5000 microstrain
Strain Gage Read-Out	Budd	Budd Strain Indicator Model P-350
2-inch Extensometer	Tinius-Olsen	Model 2-AB
10-inch Extensometer	Tinius-Olsen	Model S-1

(a) (790844-3) Overall View of Setup

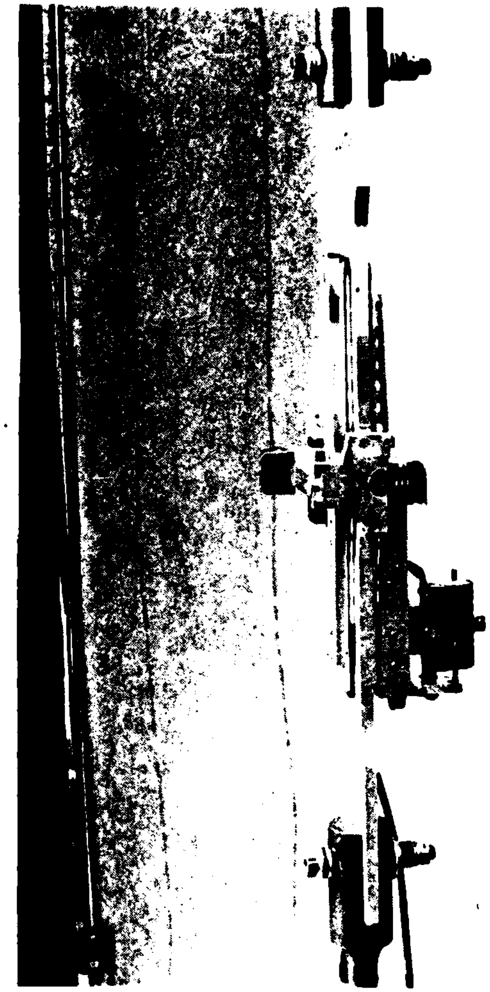


(b) (790844-4) Extensometer Installation Detail

Figure 4-9. Coupon Static Tension Test Setup in Tinius-Olsen Test Machine.

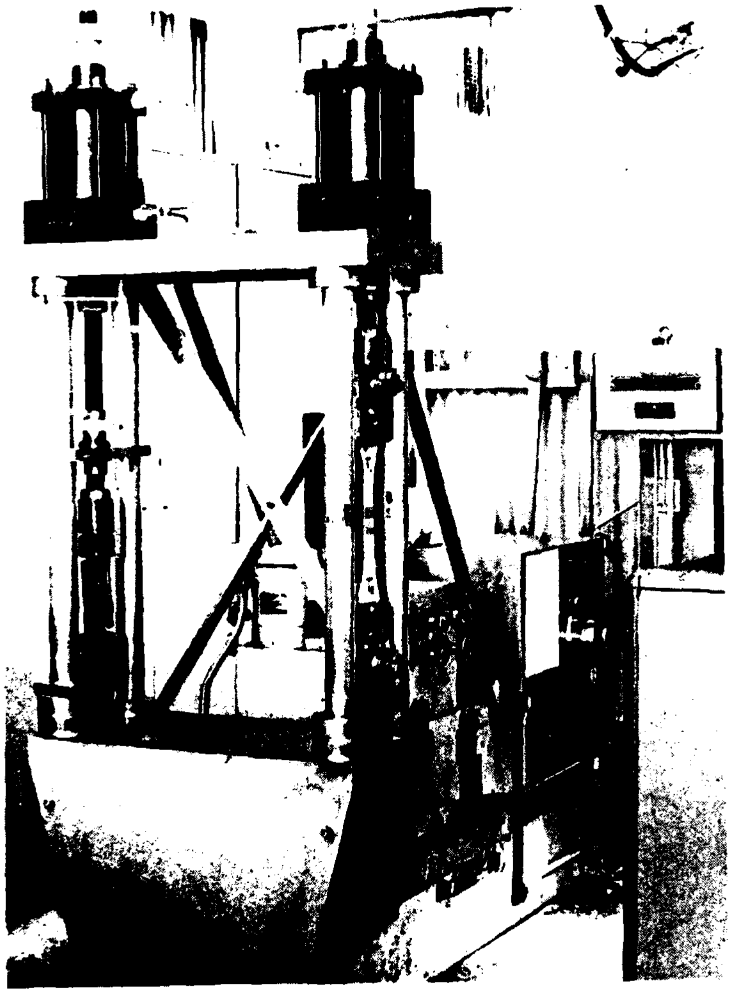


(a) (780555-1) Front View

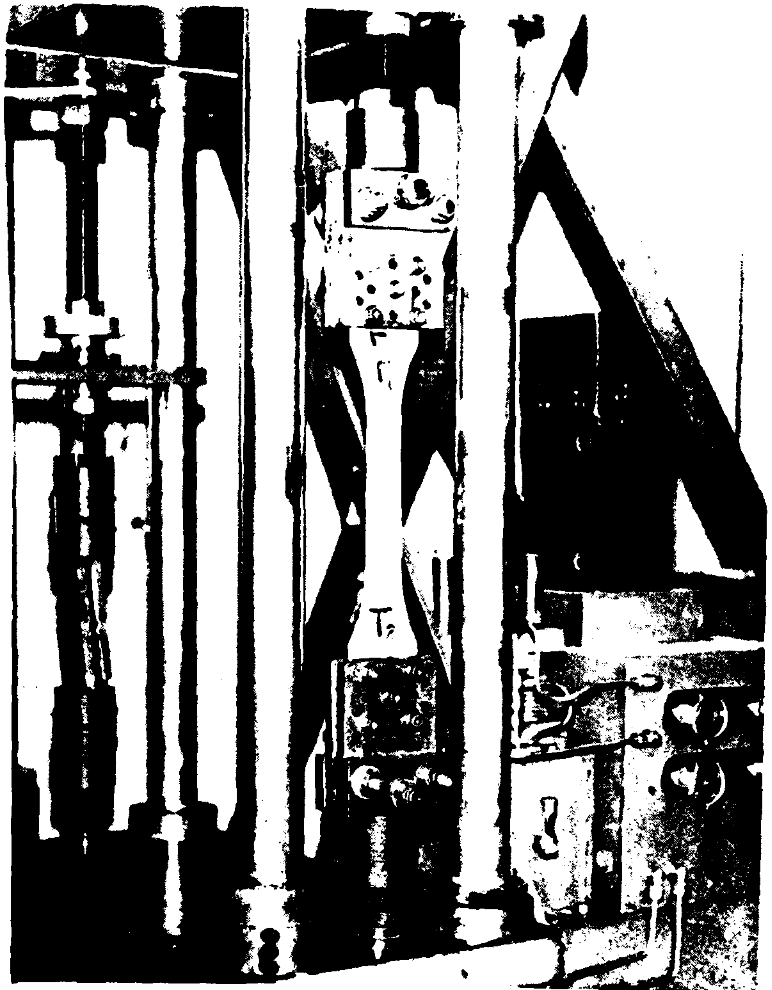


(b) (780555-2) Side View

Figure 4-10. Coupon Static Tensile Specimen Setup (Instrom Test Machine) with Dual (2-inch and 10-inch Gage Length) Extensometers Installed



(a) (790844-1) Overall View



(b) (790844-2) Detail of Specimen Installation and Grips.

Figure 4-11. Coupon Axial Tension Fatigue Test Setup in Krouse Fatigue Test Machine

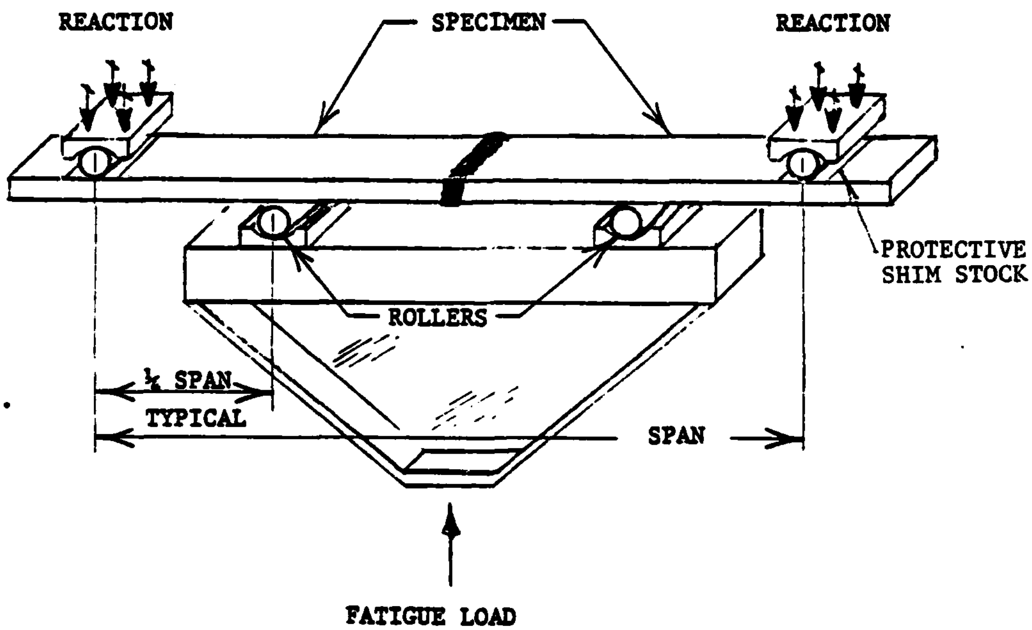


Figure 4-12. Fixturing Setup for Welded Plate Bending Fatigue Tests.

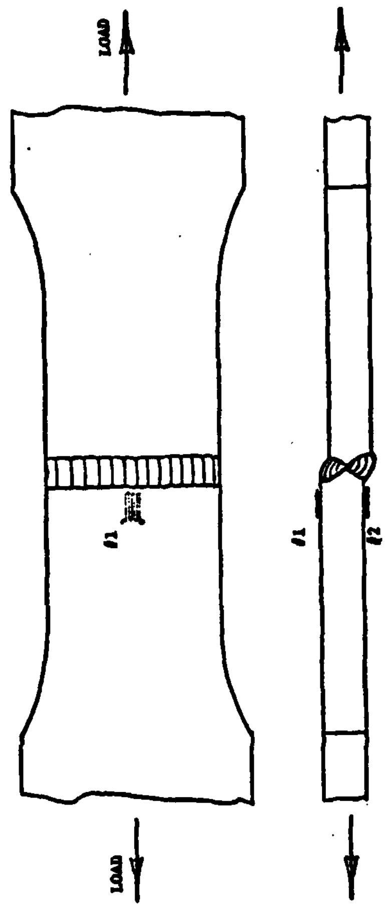


Figure 4-13. Typical Strain Gage Locations on Selected Welded Plate Static Tensile Specimens.

The Test Laboratory's Instrumentation Groupwas responsible for the implementation, checkout and calibration of all equipment used in the generation of loads and the acquisition of all data during this program. All of the instrumentation was subject to the laboratory's quality assurance provisions instituted to preserve data precisions and accuracy including National Bureau of Standards traceability. All of the instrumentation equipment and the test machines displayed current calibration certification tags. Certain items required scheduled re-calibration during the course of testing, and this task was performed prior to the expiration data of the affixed calibration tag. No significant changes in calibration were detected in any item. The calibration systems conformed to MIL-C-45662A.

4.6 TEST PROCEDURES

4.6.1 STATIC TENSION TESTS -- The welded plate static axial tensile tests were performed in accordance with FED-STD-151a, Method 211.1 (Reference 11) except for gage length variations as indicated in Paragraph 4.2.1 above.

Pre-test specimen preparations and measurements were performed as described in Paragraph 4.2.2. The extensometer(s) for yield determination, and when applicable, strain gages to define local strain distribution were connected to appropriate read-out instrumentation after the soecimen was installed in the test fixture.

Results obtained consisted of yield and ultimate strength, elongation and failure mode. Yield stress, based on the 0.2 percent strain offset definition over the applicable gage length, was determined from the extensometer autographic plot(s). Visual examination of all specimen fracture surfaces was performed to document origins of failures, abnormalities, etc. Photographs were taken to illustrate typical failures.

4.6.2 TENSILE FATIGUE TESTS -- The welded plate tensile fatigue tests were performed in accordance with ASTM-E466 (Reference 13). Pre-test specimen preparations and measurements were performed as described in Paragraph 4.2.2 above, and the specimen was installed in the test fixture. All tests were of constant load amplitude at a stress ratio of R = 0.1. Load magnitudes were individually selected with the intent of precipitating specimen failure between 100,000 and 1,000,000 ("run-out") cycles. In an effort to complete the data base, specimens which were removed from testing after sustaining 1,000,000 cycles were subsequently retested at a stress level at least 25 percent higher than that for the original run-out test in order to minimize the effect of any previous fatigue damage.

Visual examination of all fatigue specimen fracture surfaces was performed to determine mode of failure and any abnormalities. Photographs were taken to illustrate significant or typical characteristics.

4.6.3 BENDING FATIGUE TESTS -- Bending fatigue test specimens were prepared and measured as described above in Paragraph 4.2.2. Each specimen was installed in the test fixture and loaded as a simply supported beam with a uniform moment across the test section as shown in Figure 4-12. Procedures for load determination, repeat testing of run-out specimens and failure mode review were as described above for the tensile fatigue tests.

4.7 TEST RESULTS

Tensile static and fatigue test results for butt and fillet welded plate coupon specimens are summarized below. Additional detailed data recorded during these tests are included in Appendix C for reference.

4.7.1 BUTT WELDED SPECIMENS -- Axial static tension, axial fatigue, and bending fatigue test results for butt weld plate coupon specimens are presented below.

4.7.1.1 Static Tensile Results -- Static tension data for the butt welded plate specimens is tabulated in Table 4-6 and graphically depicted in Figure 4-14. Results from the specimens containing intentional weld imperfections, i.e., excessive porosity and lack of fushion/lack of penetration indications, are included in these data summaries. Copies of the laboratory data sheets covering all of the static tensile test plate specimens are included in Section 1.2 of Appendix C.

For all fillet welded specimens and most of the butt welded specimen types, measured static tensile strengths exceeded the 3KSES design allowables or published minimum values, as applicable. (For reference, 3KSES design strength values for butt welded joints were 40 ksi ultimate tensile strength and 26 ski tensile yield strength based on a 10-inch gage length; from Reference 15, published minimum yield strength for a 2-inch gage length is 20 ksi.). Specimens failing to meet minimum requirements included three specimens with offset mismatch at the butt joint which were deficient in yield strength (2-inch gage length) with measured values as low as 17.8 kwi. A total of seven specimens with offset mismatch failed to reach the required ultimate tensile strength level; measured strengths ranged from 32.4 to 39.8 ksi. Also, all of the butt joint specimens containing porosity levels exceeding 7.5 percent and all but two of the specimens containing deliberate lack of penetration/lack of fushion imperfections fell below the required ultimate strength; measured values ranged from 31.9 to 38.1 ksi.

From a review of the test data, several general trends were evident regarding the influence of specific weld conditions on the achieved static strength performance of simple butt welded joints. These trends included the following:

a. Weld Type: Butt welds made from both sides demonstrated substantial strength improvement over welds made from one side. This strength improvement was also apparent for welds made from both sides which contained low porosity levels (be (below 5 percent).

Table 4-6. Butt Welded Plate Coupon Static Tensile Strength Test Results. (Sheet 1 of 2)

WELD JOINT CONFIGURATION	NOMINAL THICKNESS INCH	SPECIMEN NO.	SPECIMEN DWG. NO.	TEST SECTION DIMENSIONS WIDTH INCH	THICK INCH	AREA $INCH^2$	TEST RESULTS: YIELD STRENGTH 2" g.l. (10" g.l.) KSI	YIELD STRENGTH AVG 2" (10")	ULTIMATE STRENGTH KSI	ULTIMATE STRENGTH AVG	ELONGATION % 2" g.l. (10" g.l.)	COMMENTS	FAILURE LOCATION	FRACTURE SURFACE CONDITION
Butt welded from one side, baseline	.313-.313	1	TT802016-21	1.505	.314	.473	25.4 (32.0)		47.6		10.7 (3.8)		Weld toe	Clear
		2		1.504	.316	.474	25.5 (32.5)		47.8		11.3 (4.3)			
		3		1.505	.311	.468	26.5 (32.7)	25.8 (32.4)	48.1	47.8	10.8 (4.0)			
Mismatch		1	-7	1.503	.311	.467	21.1		42.7		8.5	∆ = .08"		
"		2		1.505	.312	.469	19.5	20.3	42.2	42.5	8.5	∆ = .08"		
Reinforcement removed (RR), baseline		1	-53	1.506	.316	.474	23.8 (30.6)		46.1*		16.6 (6.7)	∆ = .015/.010" *2 grip failures		
		2		1.507	.316	.474	24.5 (30.8)		46.7		13.3 (6.3)	∆ = .015/.015"		
		3		1.508	.318	.476	24.7 (31.0)	24.3 (30.8)	44.8	45.8	10.2 (3.8)	∆ = .015/.025"		
Mismatch		1	-26	1.502	.312	.469			42.4			∆, ∆ = .06", ∆ = flush	Through weld	
"		2		1.506	.313	.471	19.2		42.3	42.4	13.3	∆ = .06" ∆ = flush	" "	
Misalign		1	-33	1.503	.310	.466	20.8	20.8	43.7		9.6	∆ = .015/.015"	Weld toe	
"		2		1.483	.311	.464			45.7	44.7		∆, ∆ = .015/.015"	Through weld	
Repair		1	-43	1.504	.316	.473	20.1		46.2		12.9	∆ = <.005/.005"	Weld toe/weld	
"		2		1.506	.315	.474	20.9	20.5	44.0	44.6	12.1	∆ = .010/.010"	" " "	One porosity bubble
Repair & Mismatch		1	-47	1.506	.313	.471	21.1		43.1		8.7	∆ = .06", ∆ = .040/.015"	Weld toe	Clear
		2		1.500	.312	.468	21.5	21.3	42.7	42.9	8.8	∆ = .06", ∆ = .060/.020"	" "	
Baseline	.190-.313	1	-3	1.499	.187	.286	28.4		46.4		8.5		Weld toe	
"		2		1.498	.187	.280	28.8	28.8	45.9	46.2	7.0			
Mismatch		1	-8	1.505	.186	.278	20.9		39.6		7.0	∆ = .08"		
		2		1.501	.186	.279	21.0		38.0		6.7	∆ = .08"		
		3		1.498	.185	.277	21.6		38.8		6.4	∆ = .19"		
		4		1.502	.186	.279	23.1	21.7	39.4	39.2	6.5	∆ = .19"		
RR Mismatch		1	-27	1.504	.188	.283	23.7	23.2	40.1		6.1	∆ = .180/.065		
" "		2		1.504	.187	.281			41.5	40.8		∆, ∆ = .19/.085"		
Butt welded from both sides, baseline	.313-.313	1	-119	1.501	.313	.470	29.8 (35.9)		53.6		13.1 (8.8)			
"		2		1.507	.312	.469	28.8 (34.6)	29.3 (35.2)	53.2	53.4	14.7 (9.0)			
RR		1	-136	1.502	.313	.470	24.3 (30.8)		47.2		13.8 (4.8)	∆ = .01/.01"	Weld toe	
		2		1.506	.312	.469	26.8 (33.4)		47.9		14.2 (4.8)	∆ = .01/.01"	Through weld	
		3		1.511	.311	.469	26.1 (32.3)	26.7 (32.2)	48.4	47.8	13.9 (5.0)	∆ = .01/.01"	Weld toe	Porosity
Mismatch		1	-123	1.498	.316	.472			34.1			∆, ∆ = .16"		Clear
		2		1.503	.317	.477	17.8	17.8	32.4	33.3	11.4	∆ = .17"		
	.375-.500	1	-127	1.503	.378	.566	21.3		40.0			∆, ∆ = .25/.17"		
	"	2		1.507	.378	.570	22.[illegible]	22.0	38.3	38.2	5.8	∆ = [illegible]/.16"		
Butt welded from one side, porosity imperfection	.190-.190	1	-313	1.504	.194	.297	25.5		41.3		7.0	∆ = 5.8%	Weld toe	Porosity
		2		1.506	.193	.291	25.6		41.6		7.5	[illegible] porosity		
		1	-316	1.504	.193	.290	23.8 ∆		34.4 ∆		4.9 ∆	∆ = excessive ∆		
		2		1.503	.193	.290	26.2		45.2		8.2	∆ = 6.2%		
RR		1	-301	1.509	.194	.293	24.6		38.8		6.8	∆ = 4.3%, ∆ = .025/.020"		
		2		1.507	.192	.289	21.8 ∆		38.9 ∆		7.8 ∆	Surface crack ∆		
		3		1.507	.194	.292	24.6 ∆		37.8 ∆		8.0 ∆	Surface crack ∆		
		1	-303	1.509	.194	.293	23.7		38.1		6.3	∆ = 10.9%, ∆ = .01/.02"		Clear
		2		1.508	.193	.291	23.8 ∆		36.1 ∆		6.2 ∆	Surface cracks	Through weld	Porosity
		3		1.510	.193	.291	23.2		36.6		6.2	∆ = 7.0%, ∆ = .02/.03"	" "	"
LOF T/8 imperfection		1	-317	1.504	.194	.292	26.7		33.1		4.6	LOF = .25	Through LOF	LOF/P
		2		1.504	.195	.293	26.8		37.2		4.6	LOF = .10"		
		3		1.504	.194	.291	28.9		36.9		3.9	LOF = .10"		
		4		1.507	.194	.292	29.2		36.6		4.1	LOF = .13"		
RR		1	-305	1.504	.195	.293	23.6		32.6		4.9	LOF = .10", ∆ = .01/.02"		
		2		1.503	.195	.293	24.4 ∆		46.1 ∆		10.8 ∆	LOF = .05", ∆ = .04/.03" ∆	Weld toe	Clear
		3		1.506	.195	.294	22.3 ∆		45.1 ∆		10.0 ∆	LOF = .08", ∆ = .04/.03" ∆	" "	"
		1	-307	1.507	.195	.294	23.7		33.2		4.9	LOF = .18", ∆ = .025/.020"	Through LOF	LOF/P
		2		1.503	.194	.292	22.3		31.8		4.1	LOF = .22", ∆ = .015/.025"	" "	"
		3		1.506	.194	.293	23.8 ∆		40.2 ∆		12.6 ∆	LOF = .06", ∆ = .04/.03" ∆	Weld toe	Clear

Table 4-6. Butt Welded Plate Coupon Static Tensile Strength Test Results. (Sheet 2 of 2)

WELD JOINT CONFIGURATION	NOMINAL THICKNESS INCH	SPECIMEN NO.	SPECIMEN DWG. NO.	TEST SECTION DIMENSIONS WIDTH INCH	THICK INCH	AREA $INCH^2$	YIELD STRENGTH 2" g.l. (10" g.l.) KSI	YIELD STRENGTH AVG 2" (10")	ULTIMATE STRENGTH KSI	ULTIMATE STRENGTH AVG	ELONGATION % 2" g.l. (10" g.l.)	COMMENTS	FAILURE LOCATION	FRACTURE SURFACE CONDITION
Butt welded from both sides, porosity imperfection	.375-.375	1	TT802016-327	1.501	.361	.542	29.5		53.5		14.0	Δ5 = 1.0%	Weld toe	Clear
		2		1.498	.358	.538	29.1		53.8		14.6	Δ5 = 1.8% Δ4		-
		1	-329	1.495	.361	.540	29.1 Δ4		48.5 Δ4		9.7 Δ4	Excessive porosity	Through weld	Porosity
		2		1.500	.358	.538	27.8		51.4		13.0	Δ5 = 2.8%	Weld toe	Clear
RR		1	-310	1.501	.369	.554	26.8		44.3		8.1	Δ3 = .01/.02", Δ5 No report		Porosity
		2		1.502	.368	.553	27.1		43.2		8.3	Δ3 = .01/.02", Δ5 No report		
		1	-321	1.504	.356	.535	26.8		49.2		11.4	Δ5 = 4.0%, Δ3 = .025/.028"	Through weld	
		2		1.498	.357	.535	26.8		46.8		11.3	Δ5 = 4.7%, Δ3 = .030/.026"	Weld toe	
		3		1.503	.357	.537	26.6		44.7		9.2	Δ5 = 7.5%, Δ3 = .030/.030"	" "	
Fillet weld transverse shear, cruciform	.180	1	-201	1.506	.183	.276	32.8*		42.6		3.2*	* 6" gage length	Fillet	Clear
		2		1.506	.184	.277	33.7*		42.4		3.2*			
		3		1.502	.184	.276	33.3*	33.3	43.1	42.7	3.3*			
	.500	1	-205	1.506	.506	.762	26.4*		38.5		4.8*			
		2		1.499	.505	.757	27.8*		30.0		4.7*			
		3		1.506	.505	.760	27.2*	27.1	30.1	30.2	4.5*			
	.750	1	-209	1.510	.760	1.148	30.3*		44.8		6.9*			
		2		1.506	.760	1.145	30.2*		46.6		7.5*			
		3		1.511	.759	1.147	30.1*	30.2	45.7	45.7	7.2*			

NOTES.

Δ1 STRAIN GAGED SPECIMEN

Δ2 MISMATCHED SPECIMEN JOINT OFFSET

Δ3 REINFORCEMENT HEIGHT AFTER REMOVAL - SIDE 1/SIDE 2

Δ4 INVALID SPECIMEN - UNACCEPTABLE IMPERFECTION

Δ5 POROSITY LEVEL

Δ6 LOF/P = LACK OF FUSION/PENETRATION

RR = REINFORCEMENT REMOVED

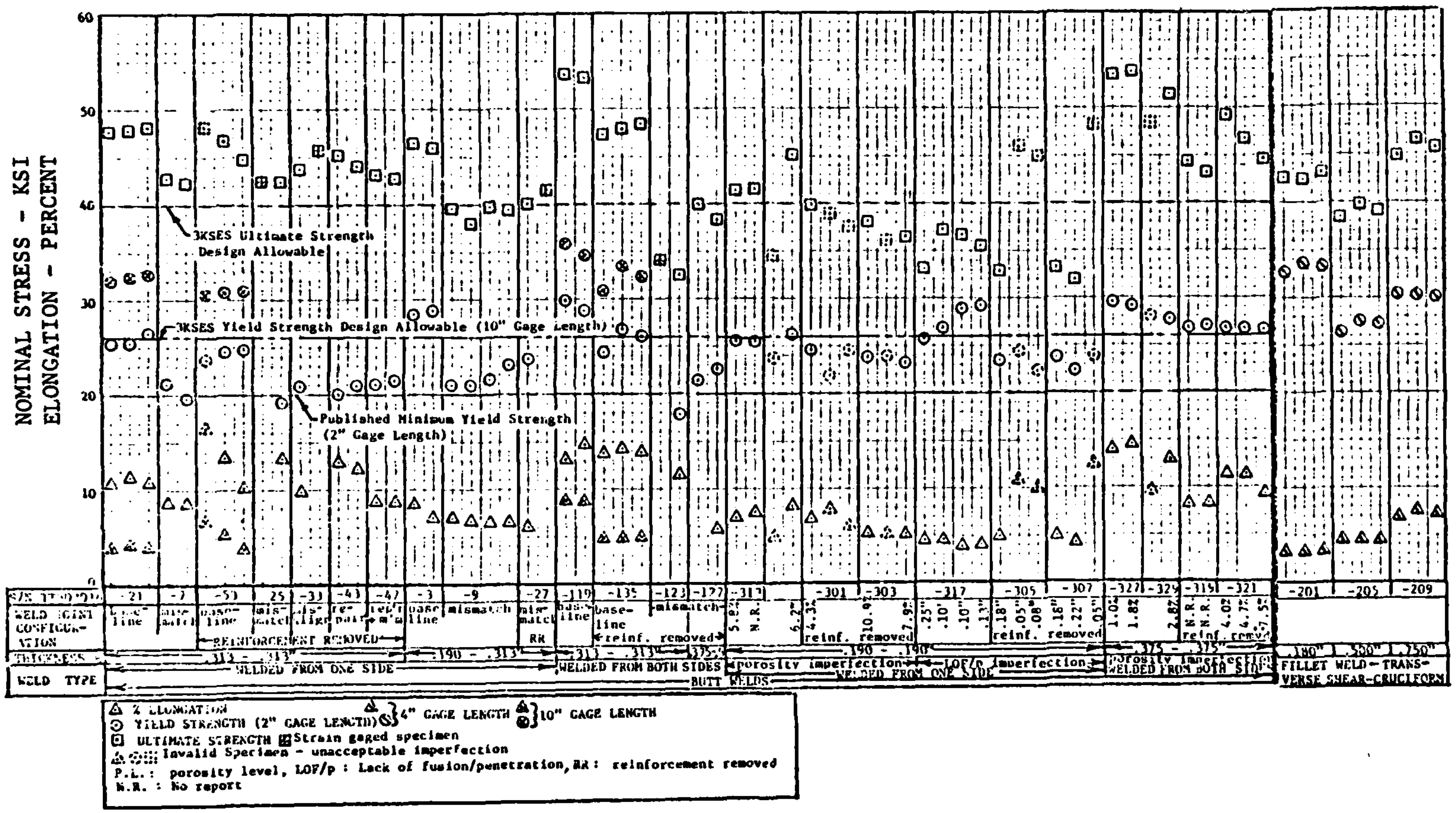


Figure 4-14. Welded Plate Coupon Static Tensile Test Results.

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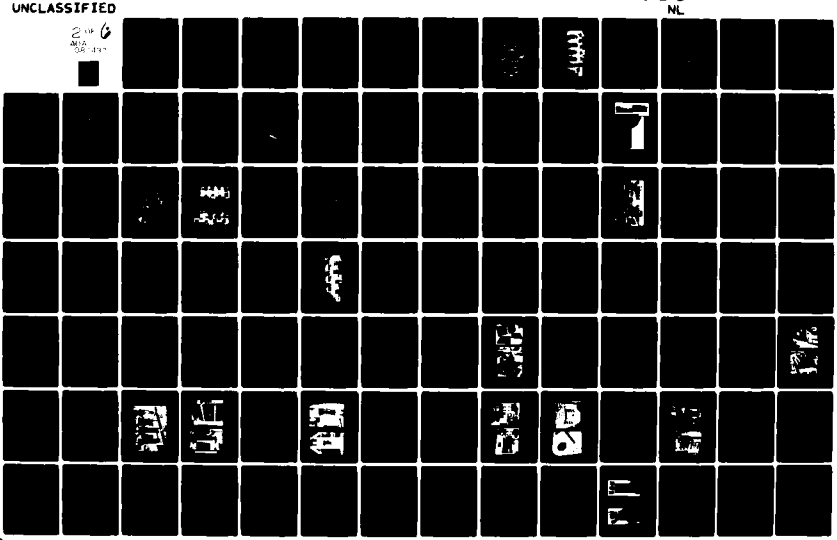
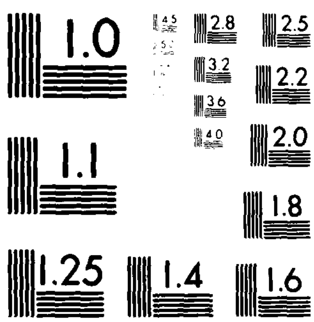




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

b. Weld Geometry and Repairs: A comparison of mismatched, misaligned and repaired specimen strengths is provided in Table 4-7. As indicated, mismatched joint welds imposed the greatest of the three strength reductions. Typical mismatched specimen strain gage readings showing the effects of the local bending induced by the eccentric joints is shown in Figure 4-15. (Complete tabulations of the recorded strain data from all strain gaged specimens with offset mismatch or angular misalignment at the butt weld joint are included in Section 1.3 of Appendix C.)

c. Post-Weld Processing: Removal of the butt weld reinforcement generally reduced baseline strength levels except for specimens joining 0.190 to 0.313 inch thick material where a slight improvement was obtained. Yield and ultimate strength reductions were attributed to the reduced area of the failure shear plane through the weaker weld metal zone. The reduced strength condition was also observed for the weld imperfection lack of fushion/penetration and porosity specimens as illustrated in Figures 4-16 and 4-17, respectively. The remaining weld reinformcement height after the removal process was generally greater than 0.01 inch and measurements up to 0.05 inch were encountered, although the maximum specified weld reinforcement height after removal was 0.03 inch. As a result of this condition, the distinction between "reinforcement removed" and "reinforcement intact" was negated in some cases.

d. Weld Imperfections: The effects of lack of fushion/penetration and excessive porosity on static strength are shown in Figures 4-16 and 4-17, respectively. Lower levels of weld imperfections did not degrade baseline strength. This fact was evident when visual examination of the specimen fracture faces reveaded the absence of imperfections as noted in the above figures.

Table 4-7. Static Tensile Strength Comparisons for Baseline, Mismatched, Misaligned, and Repaired Butt Weld Joints.

WELD JOINT CONFIGURATION	Thickness (inch)	Offset		Yield Strength		Ultimate Strength	
		Avg. (inch)	% of Thickness	Avg. (2" g.l.) (ksi)	% of Baseline	Avg. (ksi)	% of Baseline
Butt welded from one side - baseline	.313 -.313	---	---	25.8	---	47.8	---
mismatch		.08	26	20.3	79	42.5	89
baseline - RR		---	---	24.3	94	45.8	96
mismatch		.07	22	19.2	79	42.4	93
repaired & mismatch		.06	19	21.3	88	42.9	94
misalign		---	---	20.8	86	44.7	98
repair		---	---	20.5	84	44.6	97
baseline	.190 -.313	---	---	28.6	---	46.2	---
mismatch		.11	58	21.7	76	39.2	85
mismatch RR		.13	68	23.7	83	40.8	88
Butt welded on both sides - baseline - RR	.313 -.313	---	---	25.7	---	47.8	---
mismatch	.313 -.313	.17	53	17.8	69	33.3	70
mismatch	.375 -.500	.09	24	22.0		39.2	

NOTE: RR = Reinforcement Removed

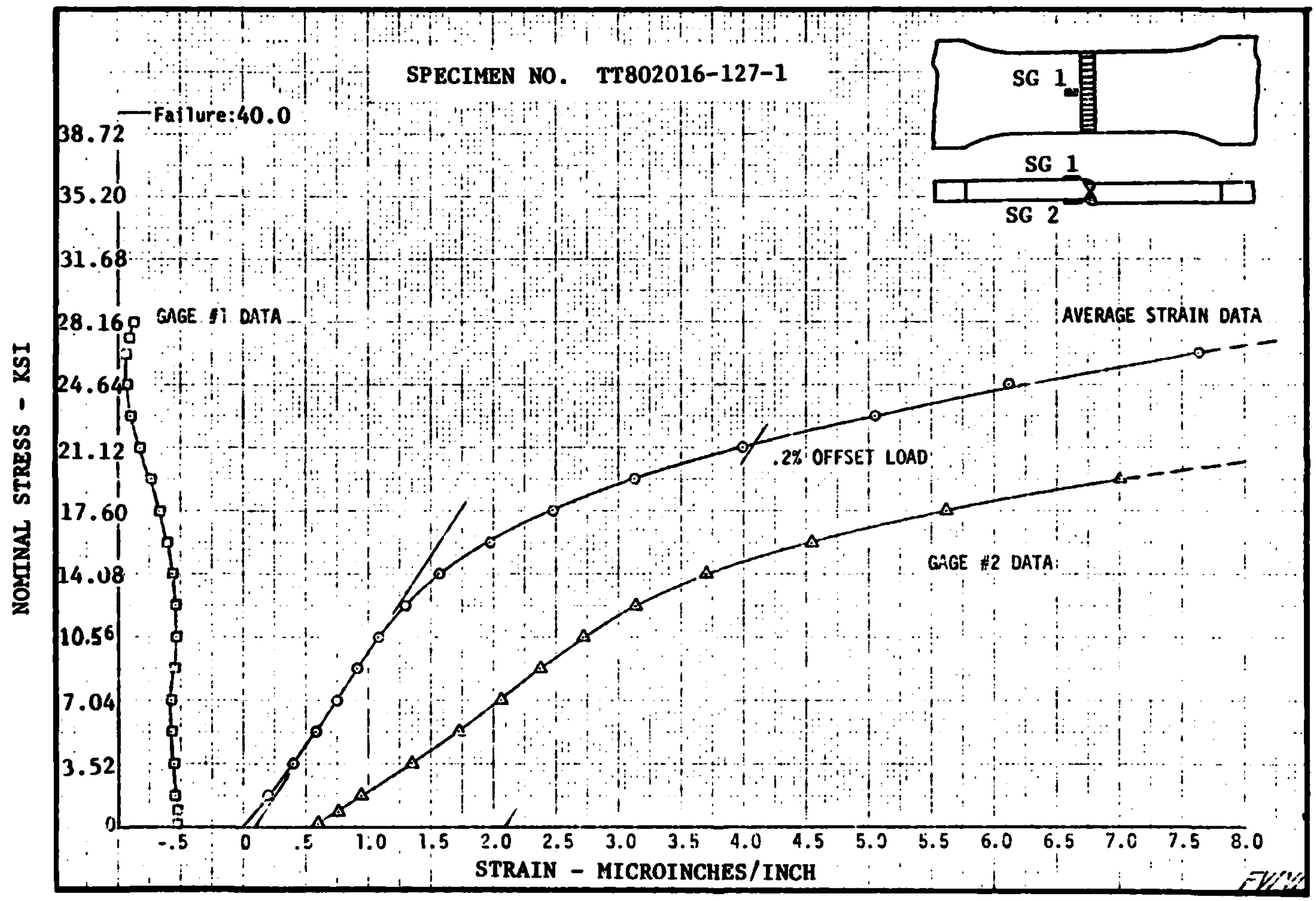
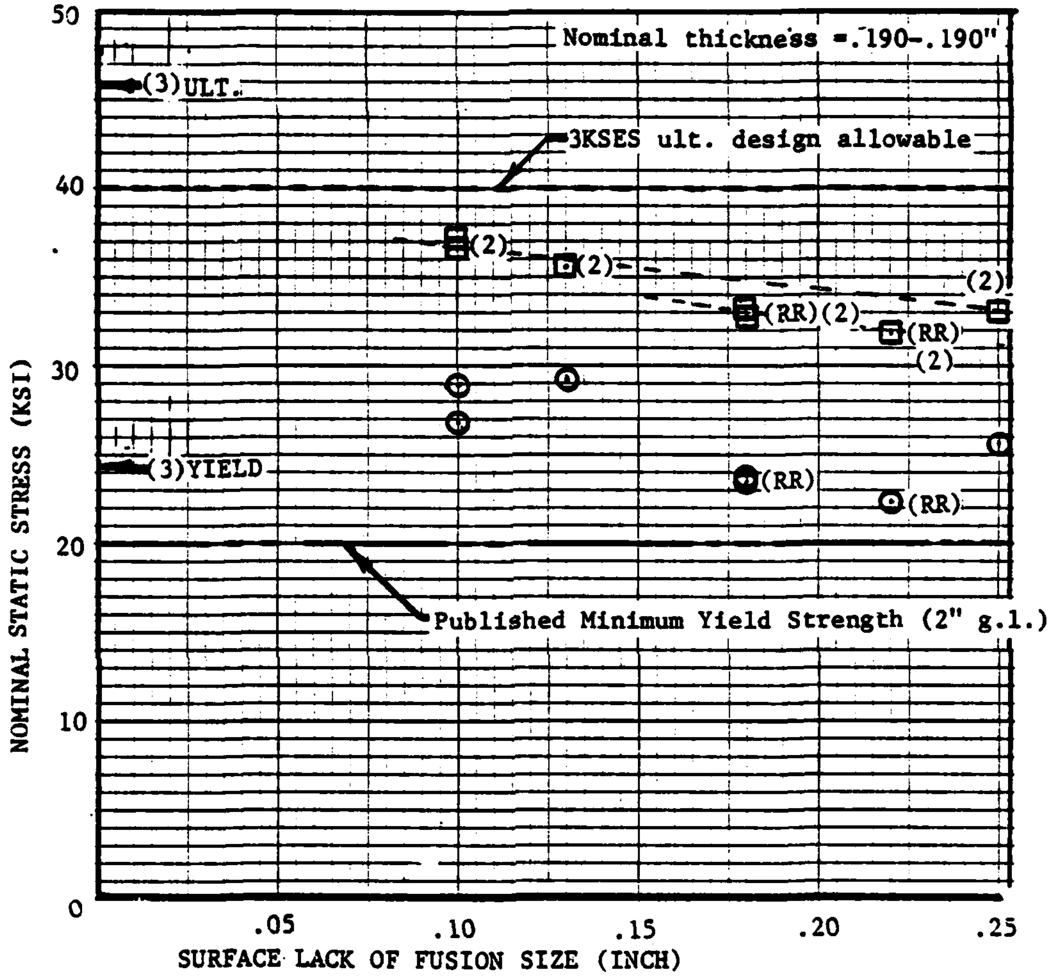
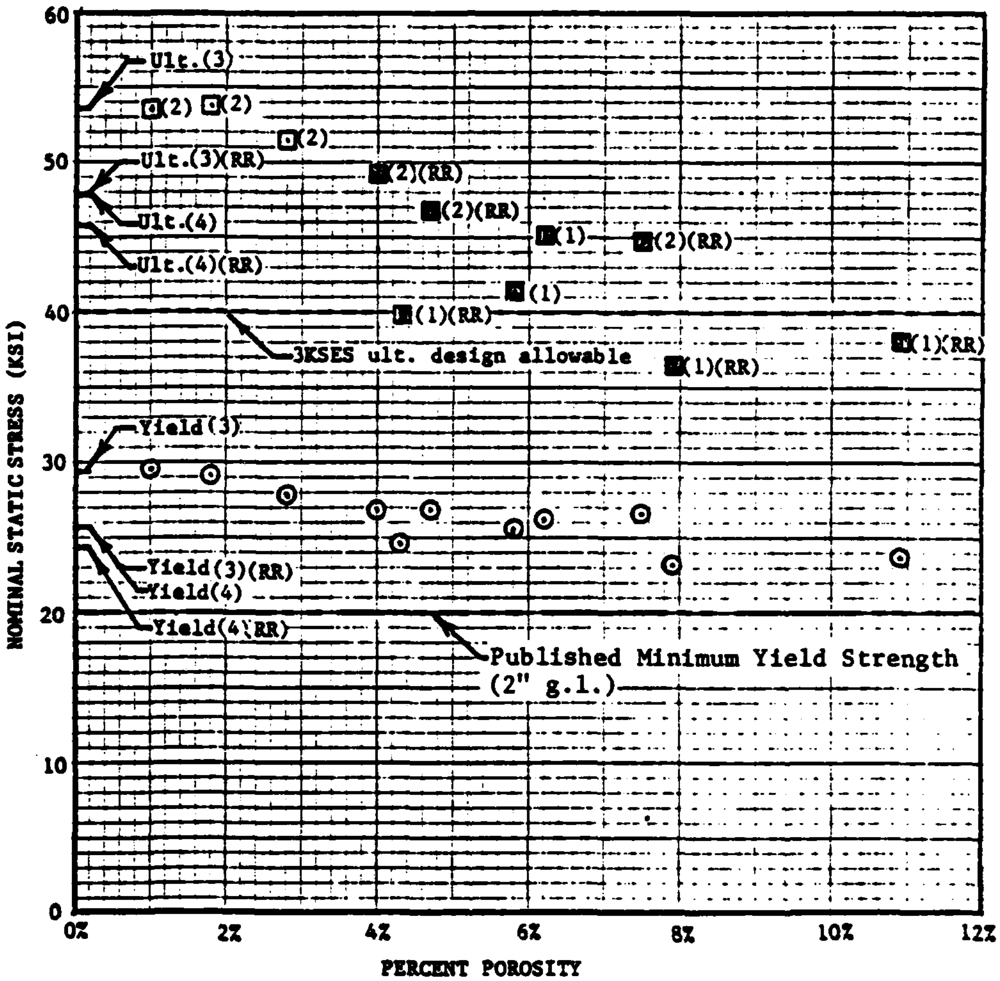


Figure 4-15. Typical Mismatched Butt Weld Static Tensile Coupon Measured Strains.



(1): Failure through weld toe
(2): Failure through Lack of fusion/penetration
(3): Nominal strength of .313" thick baseline specimens (RR)
Ultimate strength ⊙ Yield strength (2" gage length)
RR: Reinforcement Removed

Figure 4-16. Static Tensile Strength Results for Butt Welded Plate Specimens with Lack of Fusion/Penetration Imperfections.



(1): .190 inch thick welded on one side
(2): .375 inch thick welded on both sides
(3): Nominal strength of .313 inch specimens welded from both sides
(4): Nominal strength of .313 inch specimens welded from one side
RR: Reinforcement ⊙ Yield strength (2" gage length), ⊡ Ultimate strength, No Fracture Porosity
■ Ultimate Strength, Fracture Porosity Present

Figure 4-17. Static Tensile Strength Results for Butt Welded Plate Specimens with Porosity Imperfections.

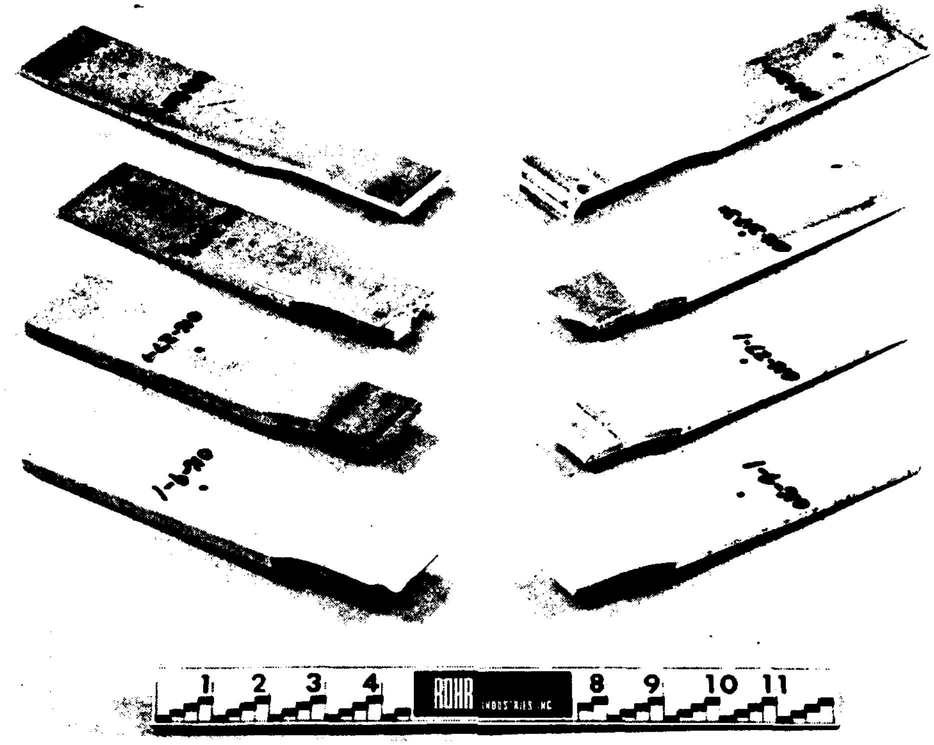
Difficulty in controlling weld imperfection levels caused some specimens to contain excessive porosity content or severe surface conditions significantly beyond the intended region of investigation. These specimens were tested but excluded from analysis.

The typical static tensile failure originated from the weld reinforcement toe into the fusion zone or from the weld toe into parent metal. In those cases where the reinforcement removal was flush with the parent metal, the failure mode was through the weld heat affected zone. Typical welded plate coupon static tensile failure modes are shown in Figure 4-18 and 4-19.

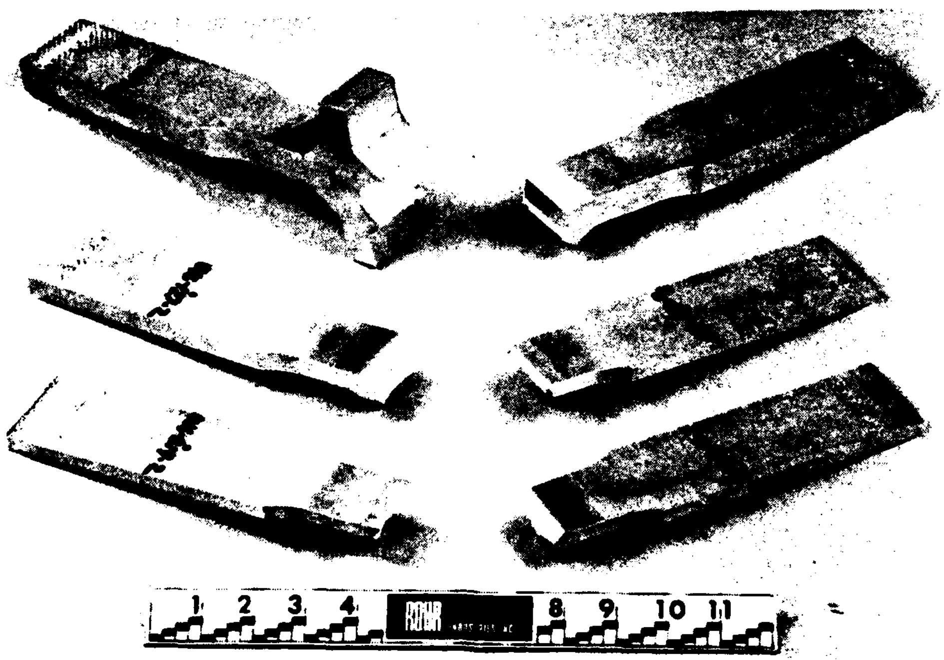
4.7.1.2 Tensile Fatigue Results — But welded coupon tensile fatigue results are presented in Figure 4-20(a) through (r). Individual test data points was well as an S-N (Maximum Stress vs No. of Cycles to Fracture) envelope are shown for each specimen type. Copies of the laboratory data sheets listing all of the welded plate coupon fatigue test specimens are included in Section 2.2 of Appendix C.

The S-N envelopes in Figures 4-20(a) through (r) were defined by theoretically derived S-N curves drawn through the lowest and the highest data points for each specimen type. Each such derived curve represented the theoretical fatigue behavior of specimens with a specific Neuber stress concentration factor. The baseline specimen fatigue test data, as a whole, correlated reasonably well with these calculated curve profiles based on a material static ultimate strength of 48 ksi, yield strength of 26 ski, and a 17 percent static reduction of area, for stress concentrations between 1.5 and 4.0.

Tensile fatigue strength comparisons at 500,000 cycles, as presented in Table 4-7A and Figure 4-21, were determined using the envelope boundary curve intercepts. In some cases, extrapolation beyond the data group life limits was necessary.



(a) (790118-3) Top to bottom: Cruiform, Butt Weld LOP Imperfection, Butt Weld (RR), Butt Weld (RI).



(b) (790118-2) Top to bottom: Cruciform, Butt Weld Dual Thickness (RI), Butt Weld Porosity Imperfection (RR).

Figure 4-18. Typical Butt and Fillet Weld Coupon Specimen Static Tensile Test Failures

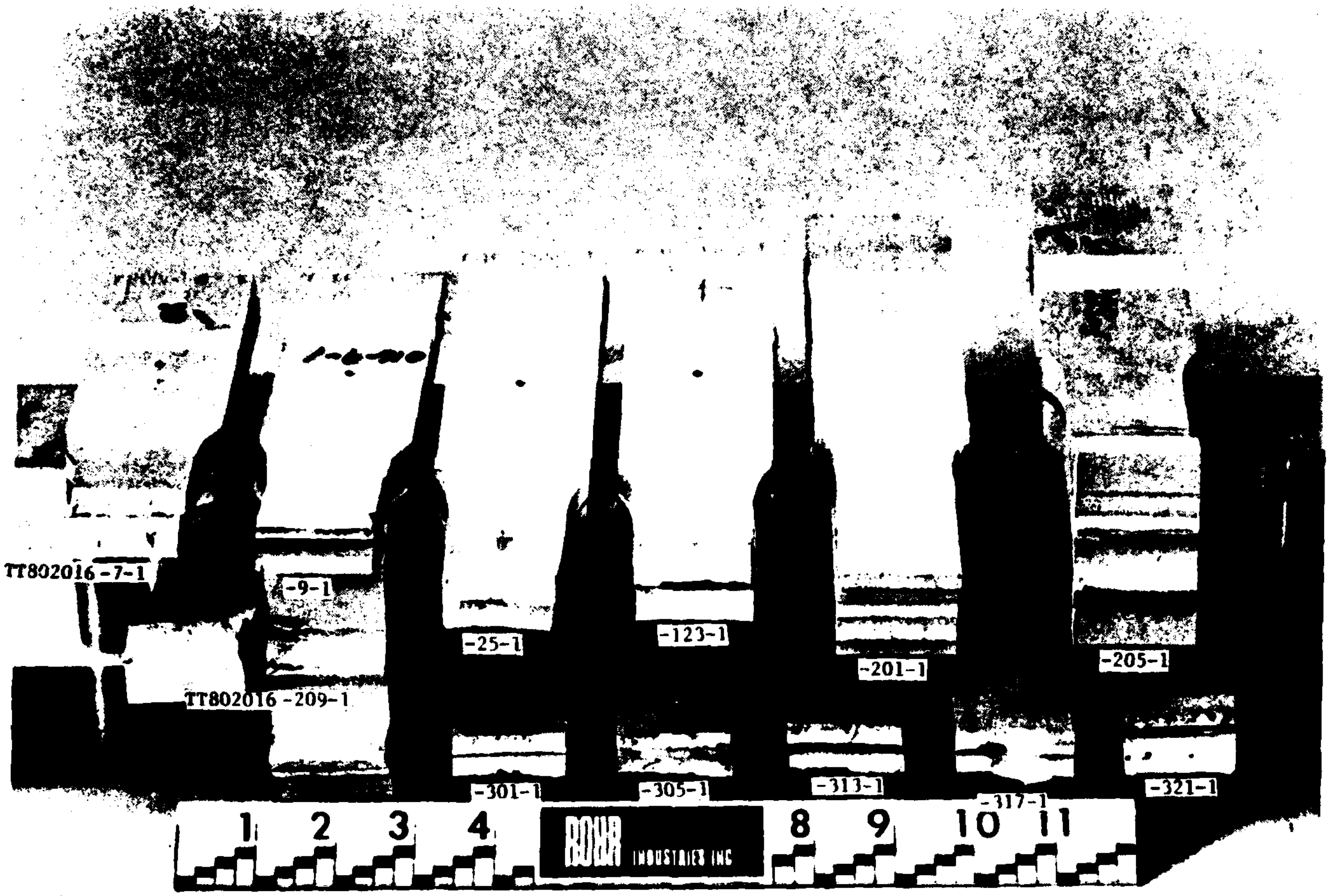


Figure 4-19. (790957-3) Butt and Fillet Welded Static Tensile Test Coupon Fracture Surfaces

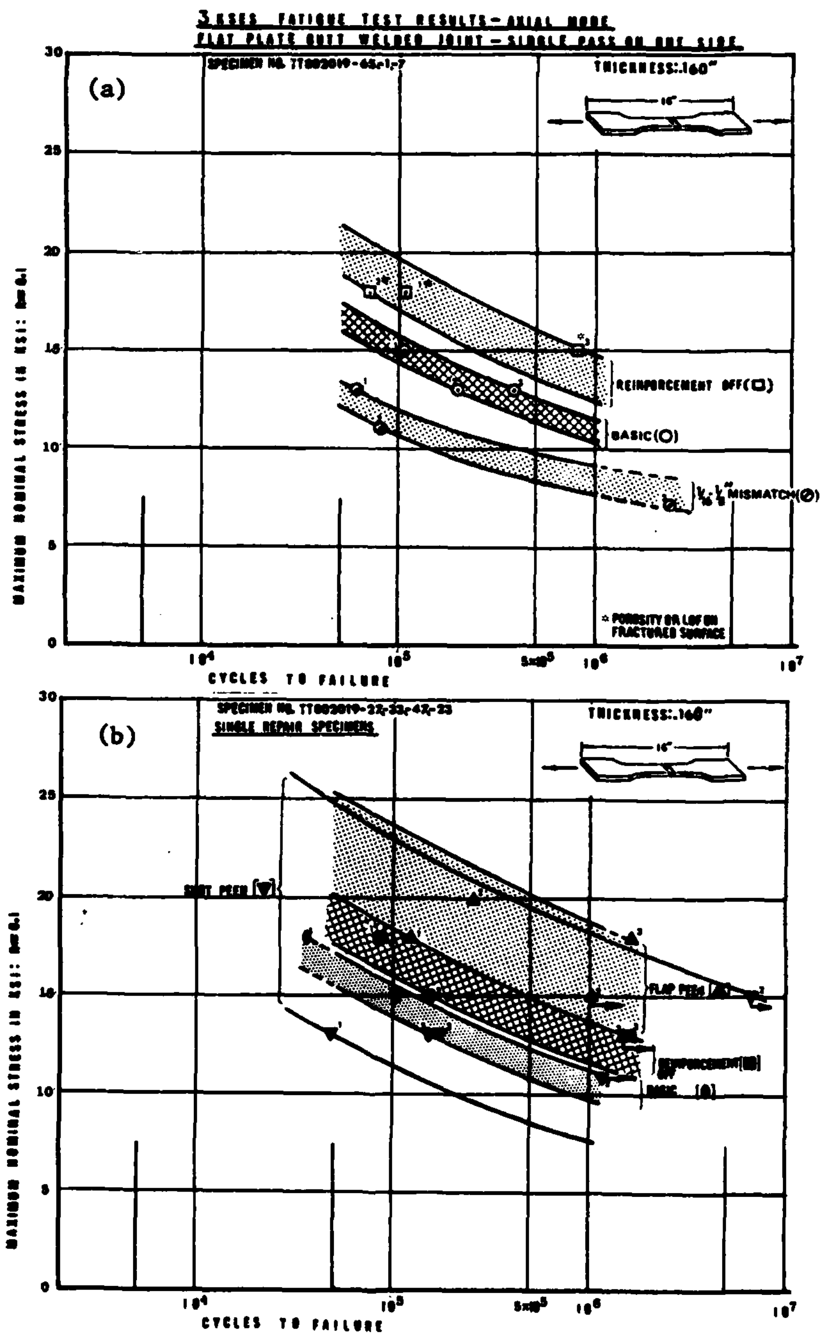
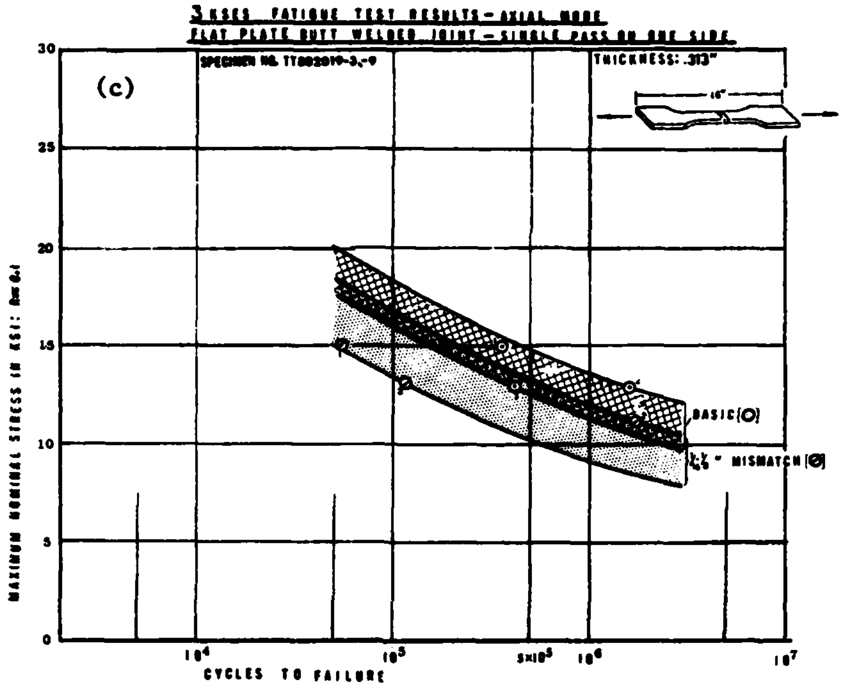


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 1 of 9)



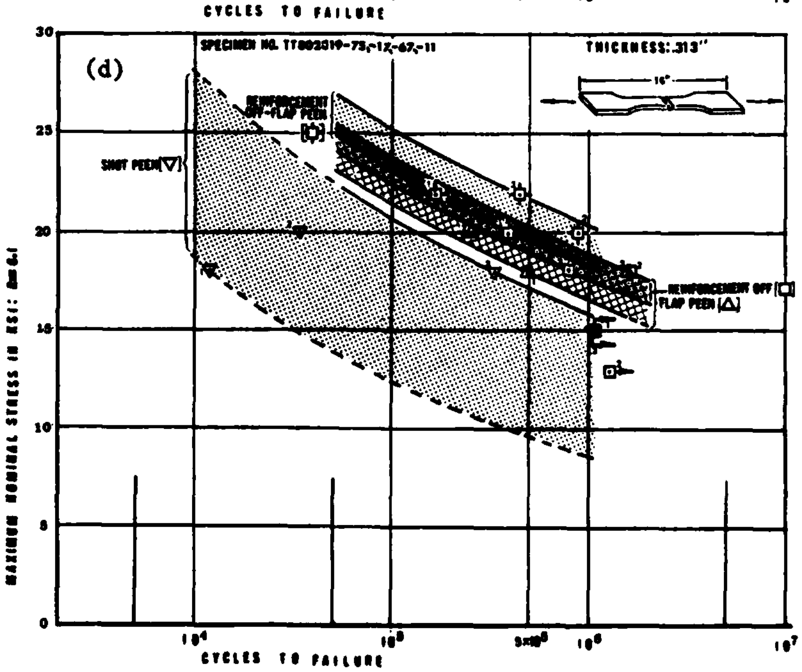


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 2 of 9)

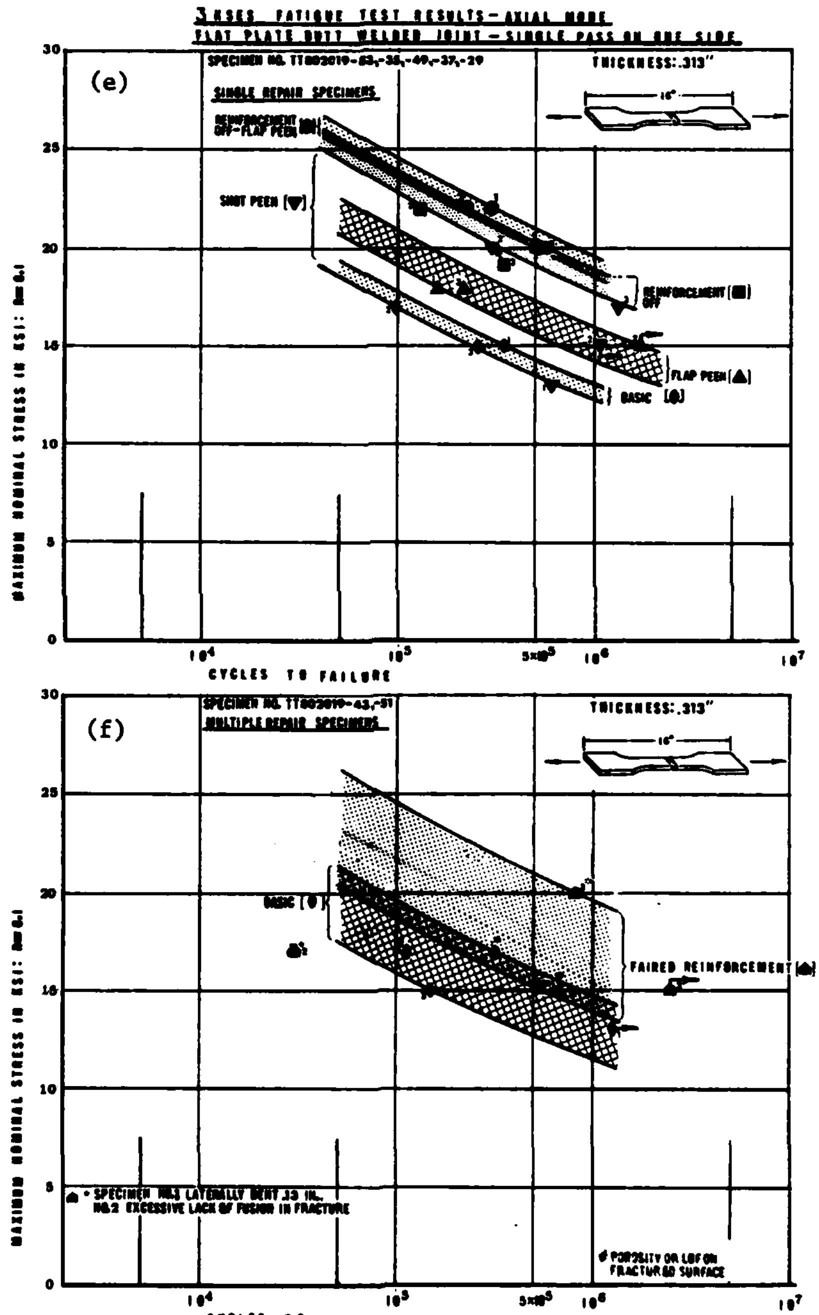


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 3 of 9)

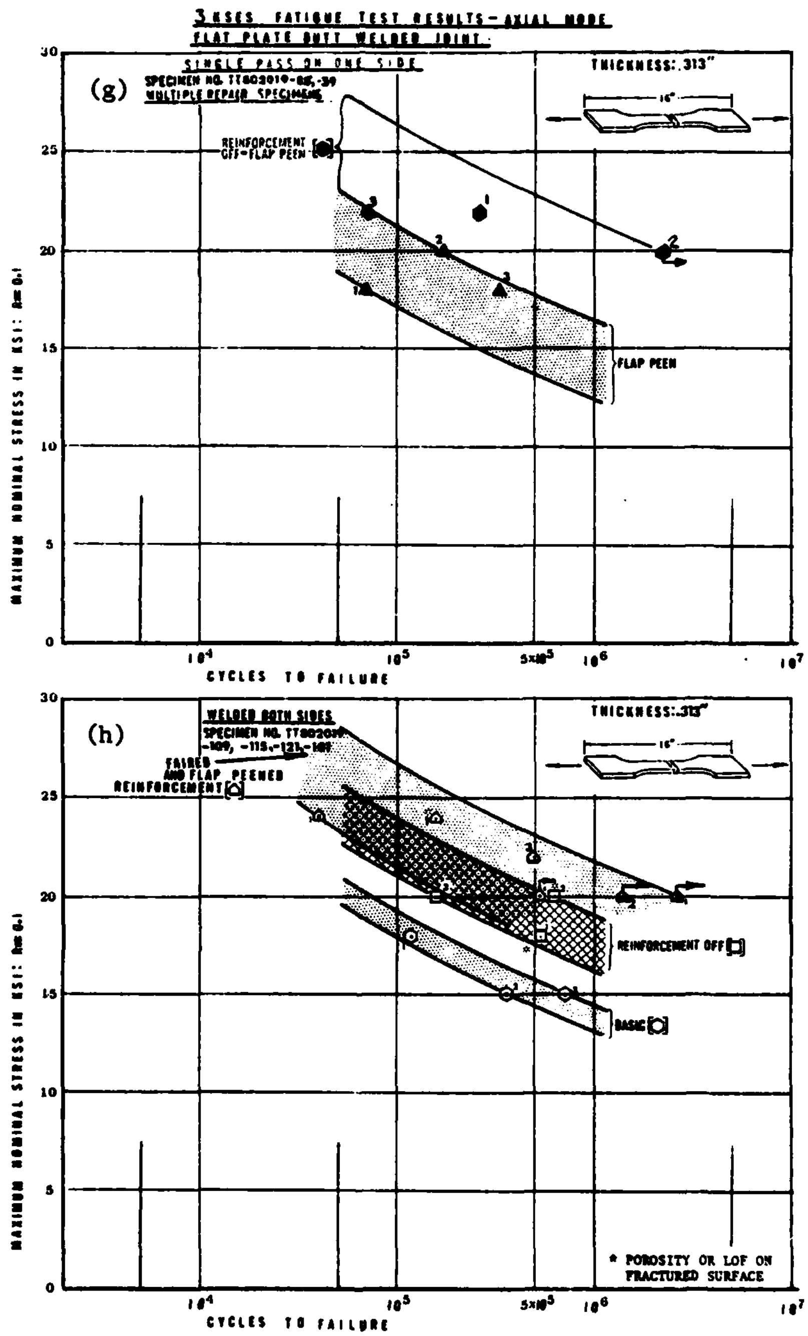


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 4 of 9)

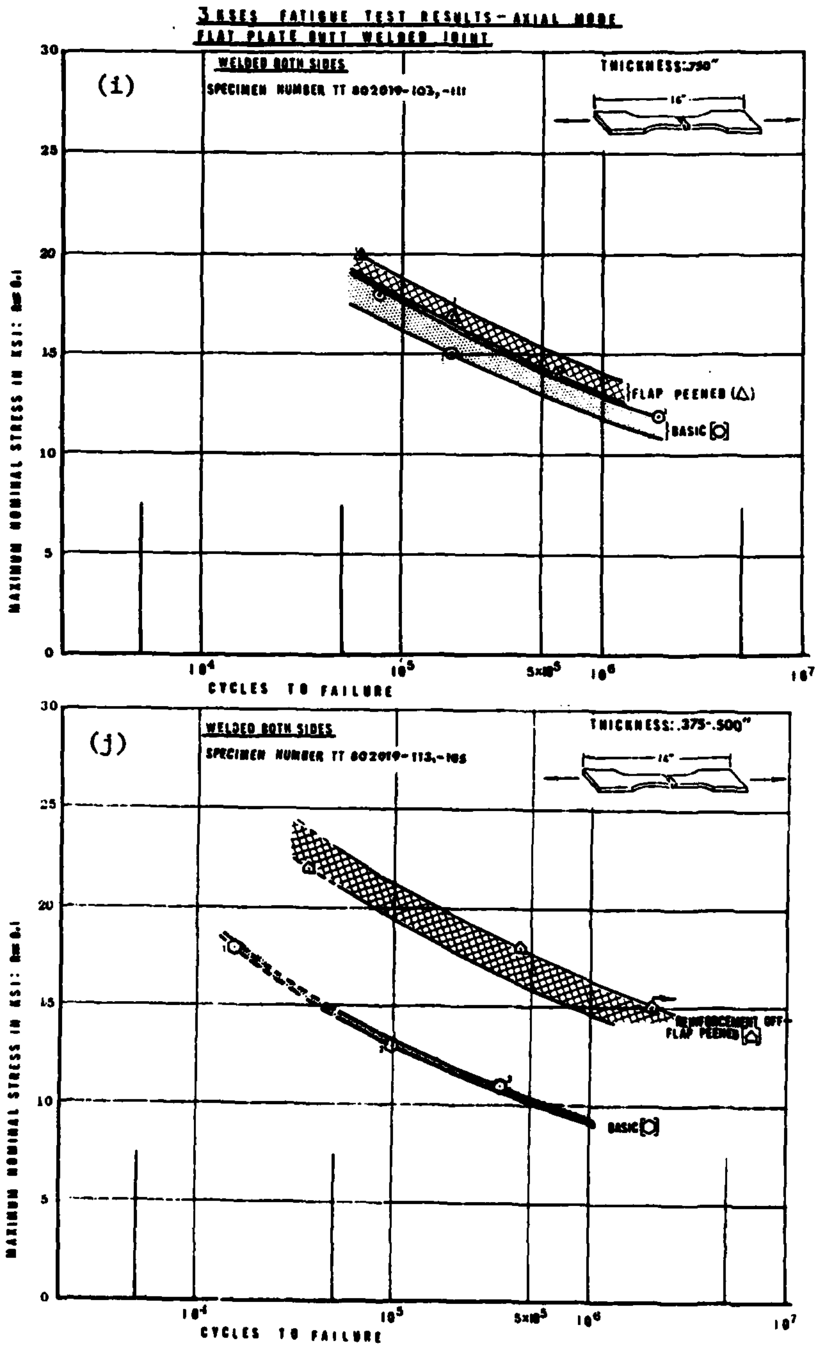


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 5 of 9)

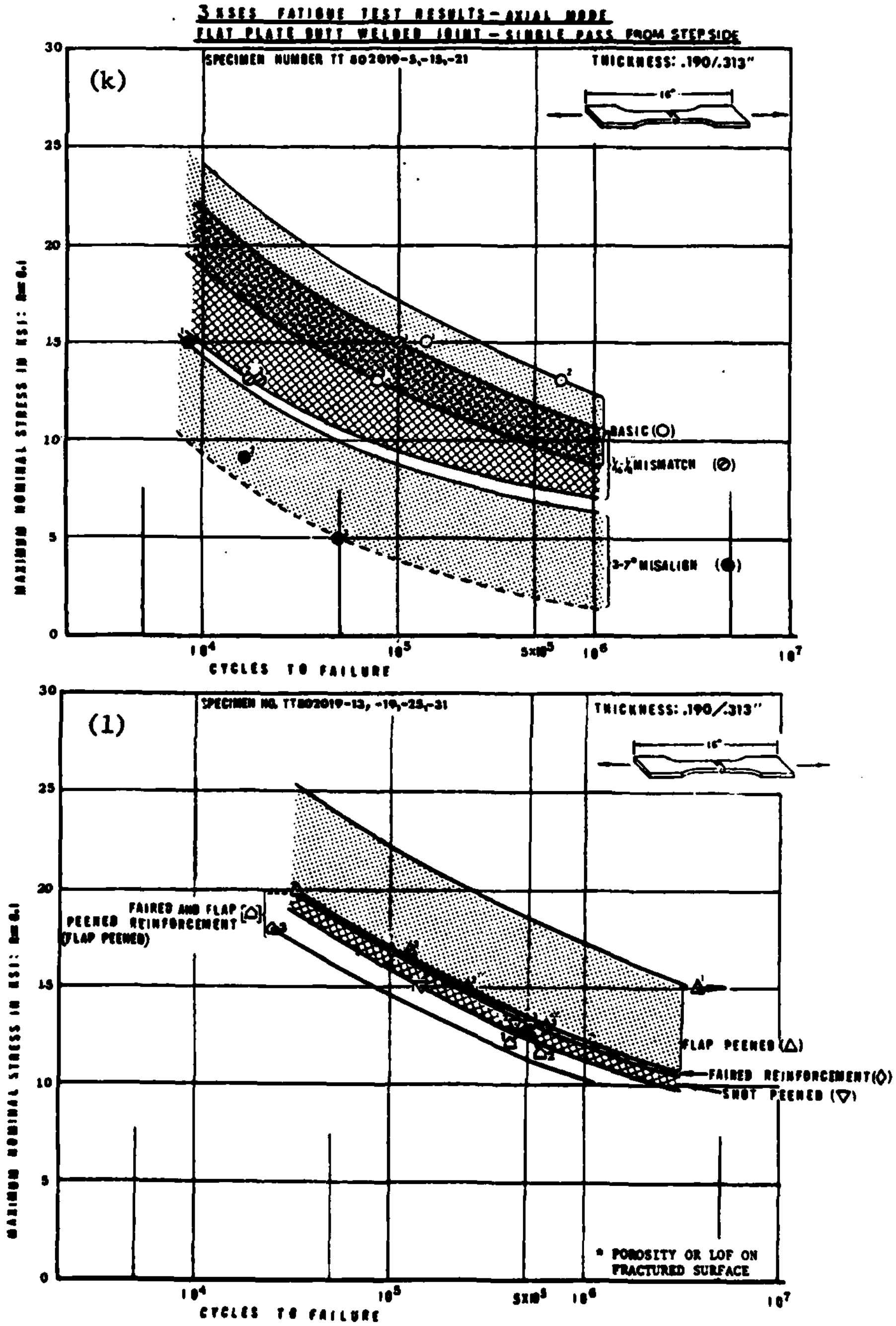


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 6 of 9)

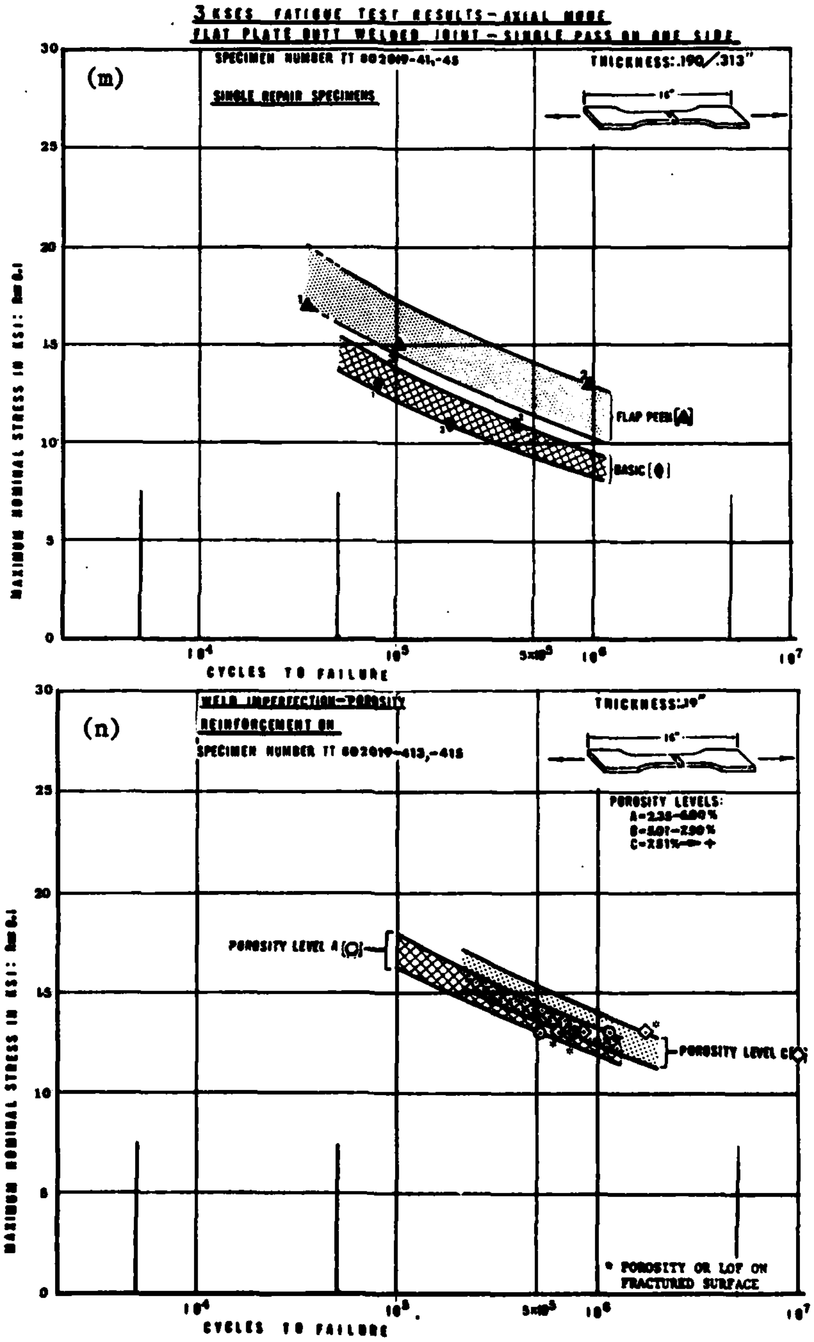


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 7 of 9)

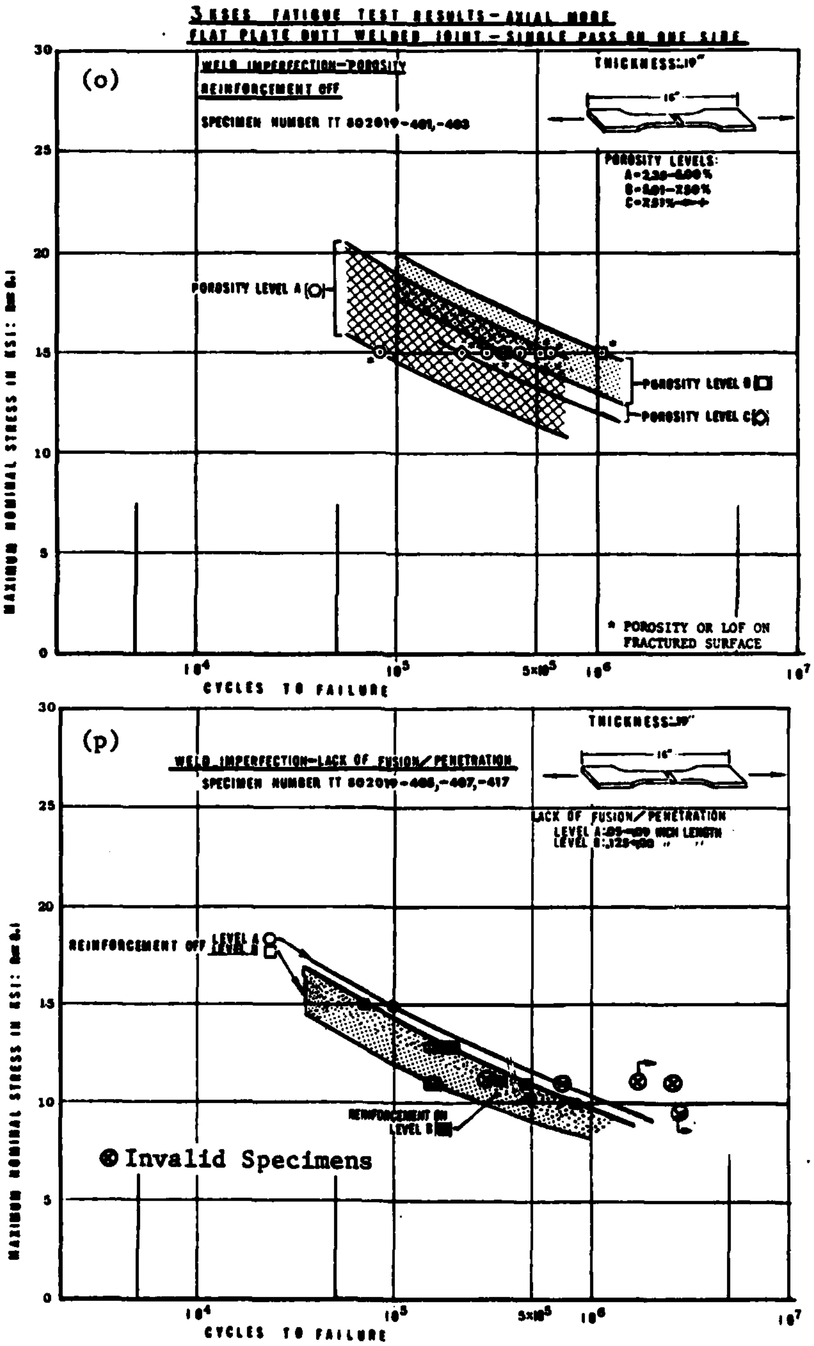


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 8 of 9)

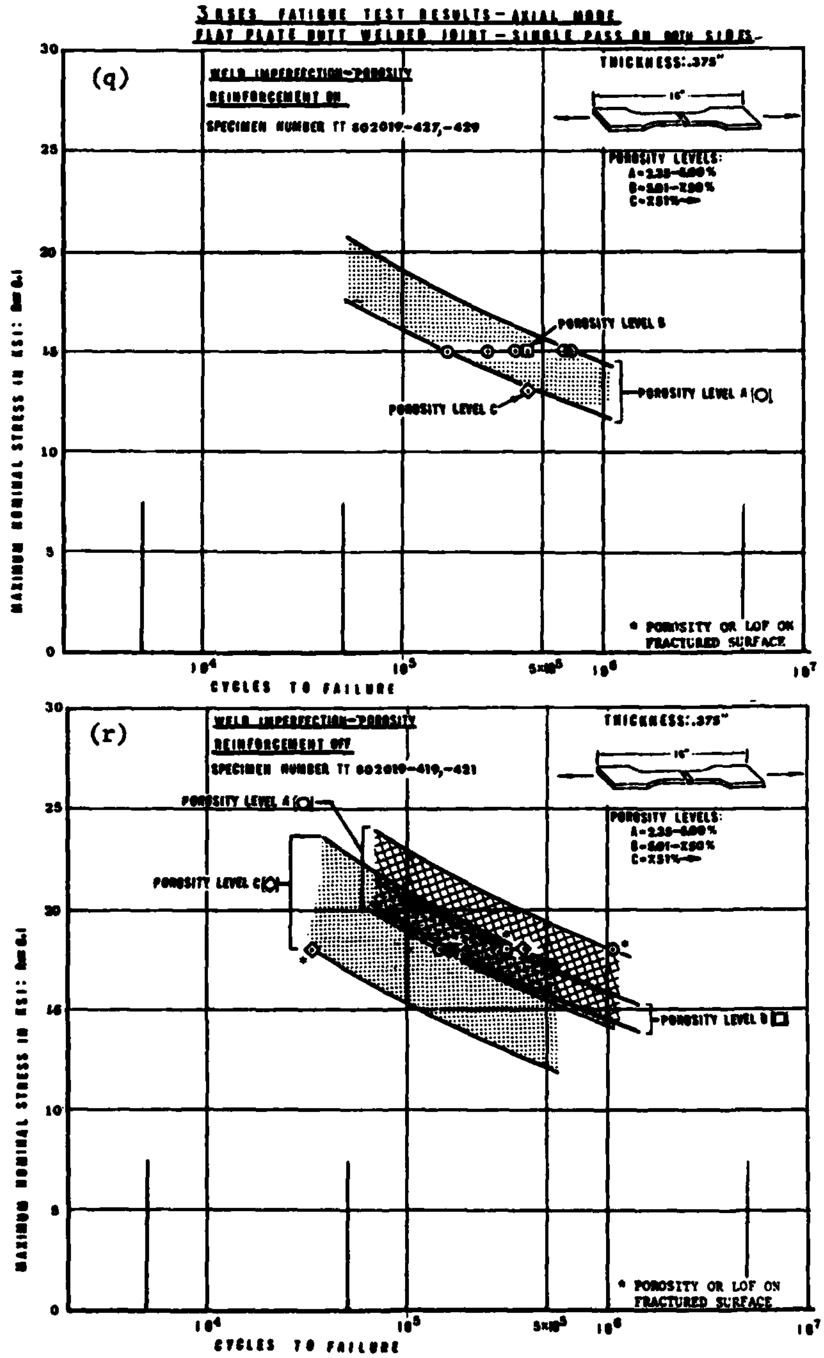


Figure 4-20. Butt Welded Plate Coupon Axial Tension Fatigue Test Results. (Sheet 9 of 9)

Test specimen weld imperfection grades as defined on the various curves, were based upon the original test plan objectives and actual specimen imperfection levels. The strengh comparison figures have these imperfection classifications included for reference.

Review of the butt welded plate specimen test data indicates fatigue strengh to be dependent on specimen thickness, weld type, weld joint geometry, post weld processing and weld imperfections. Using the data lower boundaries and scatter as evaluation criteria, fatigue strength variations can be summarized as follows:

a. Thickness: Optimum baseline weld fatigue strength was demonstrated by 0.313 inch thick specimens compared to 0.160 and 0.75 (two-sided multipass weld) thicknesses.

b. Weld Type: Butt welds made from both sides indicated significant strength improvement compared to welds made from one side for 0.313 inch thick specimens.

c. Weld Repairs: Single and multiply repaired welds demonstrated fatigue strengths comparable to baseline specimens without repair with one exception. That exception was one of the multiply repaired specimens (S/N TT802019-51, No. 2) which contained a substantial lack of fushion zone in the fracture interface as shown in Figure 4-22. Because of the presence of this defect which had not been detected during previous inspections, including radiography, data from specimen S/N TT802019-51, No. 2 was omitted from the data base.

d. Weld Joint Geometry: Joints butt welded with offset mismatch or angular misalignment demonstrated fatigue performance which was degraded from baseline strength. The effect of joint offset mismatch on fatigue strength relative to specimen thickness is shown in Figure 4-23.

e. Post-Weld Processing: Weld reinforcement removal, fairing, flap peening (with fairing) and reinforcement removal with

flap peening all demonstrated increased fatigue strength compared to baseline. The amximum strength increase was obtained from reinforcement removal with flap peen processing.

Shot peening produced large strengh variations and consequently reduced lower boundary limits below baseline data for two of the four specimen types.

Reinforcement removal produced a marginal strength improvement for butt welds containing significant porosity.

f. Weld Imperfections: The effects of porosity and lack of fushion/penetration on butt weld specimen fatigue strengths are shown graphically in Figures 4-24 through 4-26. Failure modes and features are indicated on these figures in view of the prevalent mode trends as discussed below. Several specimens containing porosity imperfections could not be validly quantified due to excessive surface porosity and cracks, and these specimens were excluded from the results presented.

Two types of failure modes became apparent during testing of the specimens with porosity conditional on the state of the weld reinforcement. Wtih the reinforcement removed, the failure mode was porosity-induced with porosity evident at the origin and on the fracture surfaces. Specimens with the reinforcement intact failed predominantly through the weld toe with little or no evidence of porosity on the fracture surfaces even at porosity levels as high as 11.5 percent. These toe failure specimens exhibited marginally lower strength than the specimens with the weld reinforcement removed. This trend was more pronounced for the 0.375 inch thick specimens. These different failure modes were attributed to the porosity-reduced cross-sectional area in those cases where the weld reinforcement was removed, and a higher stress concentration factor existing at the toe of the weld than through the porosity when the weld reinforcement was intact.

Table 4-7A. Statistical Comparisons of Butt Welded Plate Specimen Tensile Fatigue Strength.

SPECIMEN DESCRIPTION				STRENGTH AT 500,000 CYCLES MAXIMUM NOMINAL KSI; R = 0.1						FIG. NO.
TYPE WELD	Thk. Inch	Qty. Tested	Specimen Number	Low Strength	High Strength	Range	Average Strength	Std. Dev.	Avg.-(3σ Dev.)	
BUTT WELD AXIAL TENSION FATIGUE TESTS			TT802019-							
BUTT-SINGLE PASS-ONE-SIDE- BASIC	.160	3	-1	11.5	12.7	1.2	12.1	0.6	10.3	4-20(a)
MISMATCH		3	-7	6.3	9.8	1.5	6.9	0.8	6.5	
REINF. REMOVED		3	-65	13.5	16.0	2.5	14.7	1.3	10.8	
-SINGLE REPAIR BASIC		3	-23	10.8	12.3	1.5	11.6	0.8	9.2	4-20(b)
REINF. REMOVED		3	-47	12.2	15.0	2.8	13.8	1.5	9.3	
FLAP PEEN		3	-33	15.0	20.2	5.2	17.9	2.7	9.8	
SHOT PEEN		3	-27	8.5	19.5	11.0	13.1	5.7	---	
BASIC	.313	3	-3	12.5	14.8	2.3	13.9	1.2	10.3	4-20(c)
MISMATCH		3	-9	10.5	13.5	3.0	11.3	1.7	6.2	
REINF. REMOVED		3	-67	19.0	20.3	1.3	19.6	0.7	17.5	4-20(d)
FLAP PEEN		3	-11	17.8	20.3	2.5	18.9	1.3	15.0	
SHOT PEEN		3	-17	9.5	17.2	7.7	13.5	3.9	1.8	
REINF. REMOVED & FLAP PEEN		3	-75	19.6	21.8	2.2	20.9	1.1	17.6	
-SINGLE REPAIR BASIC		3	-29	13.5	14.3	0.8	13.8	0.4	12.6	4-20(e)
REINF. REMOVED		3	-49	16.7	20.3	1.6	19.3	0.9	16.6	
FLAP PEEN		3	-37	15.5	17.3	1.8	16.3	0.9	13.6	
SHOT PEEN		3	-35	13.5	18.7	5.2	16.9	3.0	7.9	
REINF. OFF AND FLAP PEEN		3	-83	20.0	21.0	1.0	20.4	0.5	19.9	
-MULT. REPAIR BASIC		3	-43	12.5	16.0	3.5	14.1	1.8	8.7	4-20(f)
REINF. FAIRED		3	-51	15.2	21.0	5.8	18.1	4.1	5.8	
FLAP PEEN		3	-39	13.7	17.7	4.0	16.2	2.2	9.6	4-20(g)
REINF. REMOVED & FLAP PEEN		3	-85	17.4	22.8	5.4	20.3	2.71	12.2	
BOTH SIDES BASIC		3	-101	14.3	15.7	1.4	14.9	0.7	12.8	4-20(h)
REINF. REMOVED		3	-121	17.5	20.5	3.0	18.7	1.6	13.9	
Combined Data: FLAP PEEN		3	-109	18.0	23.0	5.0	21.1	1.8	15.7	
Combined Data: REINF. FAIRED AND FLAP PEEN		3	-115							
BASIC	.750	3	-103	12.8	14.0	1.2	13.5	0.7	11.4	4-20(i)
FLAP PEEN	"	3	-111	14.3	15.4	1.1	14.8	0.6	13.0	
BASIC	.375/	3	-105	10.0	10.3	0.3	10.1	0.2	9.5	4-20(j)
REINF. REMOVED & FLAP PEEN	.500 "	3	-113	15.8	17.7	1.9	17.1	1.1	13.8	
ONE SIDE,- BASIC	.19/ .313	3	-5	9.7	13.7	4.0	12.0	2.1	5.7	4-20(k)
MISMATCH		3	-15	7.7	11.3	4.1	9.2	2.3	2.3	
MISALIGNED		3	-21	2.0	5.8	4.8	3.9	2.5	---	
REINF. FAIRED		3	-25	13.3	13.5	0.2	13.4	0.1	13.1	4-20(l)
Combined Data: FLAP PEEN		3	-13	11.2	18.5	7.3	13.9	2.5	6.5	
Combined Data: REINF. FAIRED AND PEENED		3	-19							
SHOT PEEN		3	-31	12.3	13.2	0.9	12.8	0.5	11.5	
Single Repair BASIC		3	-45	9.3	10.7	1.4	9.9	0.7	7.8	4-20(m)
Single Repair FLAP PEEN		3	-41	11.4	14.2	2.8	12.5	1.5	9.0	
BUTT-SINGLE PASS-ONE-SIDE-WELD IMPERFECTION POROSITY - LEVEL A	.190	3	-413,	13.1	14.5	1.4	13.8	0.7	11.7	4-20(n)
POROSITY - LEVEL C		4	-415	13.7	15.5	1.8	14.3	0.8	11.9	
REINF. REMOVED, POROSITY - LEVEL A		5		11.4	15.3	3.9	13.8	1.7	8.7	4-20(o)
- LEVEL B		3	-401, -403	14.3	16.5	2.2	15.3	1.1	12	
- LEVEL C		2		13.3	14.3	1.0	13.8	.7	11.7	
-LOF/P- LEVEL B		4	-417	10.3	11.0	0.7	10.7	.3	9.8	4-20(p)
REINF. REMOVED - LEVEL A		6	-405	11.7*	---	---	---	---	---	
REINF. REMOVED - LEVEL B		6	-407	9.0	11.0	2.0	10.1	.9	7.4	
BUTT-SINGLE PASS-BOTH SIDES WELD IMPERFECTION POROSITY - LEVEL A	.375	5		13.0	15.7	2.7	14.4	1.9	8.7	4-20(q)
- LEVEL B		1	-427, -429	14.7	14.7	---	(One Specimen Tested)			
- LEVEL C		1		12.8	12.8	---	(One Specimen Tested)			
REINF. REMOVED, POROSITY - LEVEL A		2		15.5	19.4	3.9	17.5	2.8	9.2	4-20(r)
- LEVEL B		2	-419,	15.7	17.0	1.3	16.4	0.9	13.6	
- LEVEL C		3	-421	12	17.4	5.4	15.0	2.8	6.7	

* Single valid data point

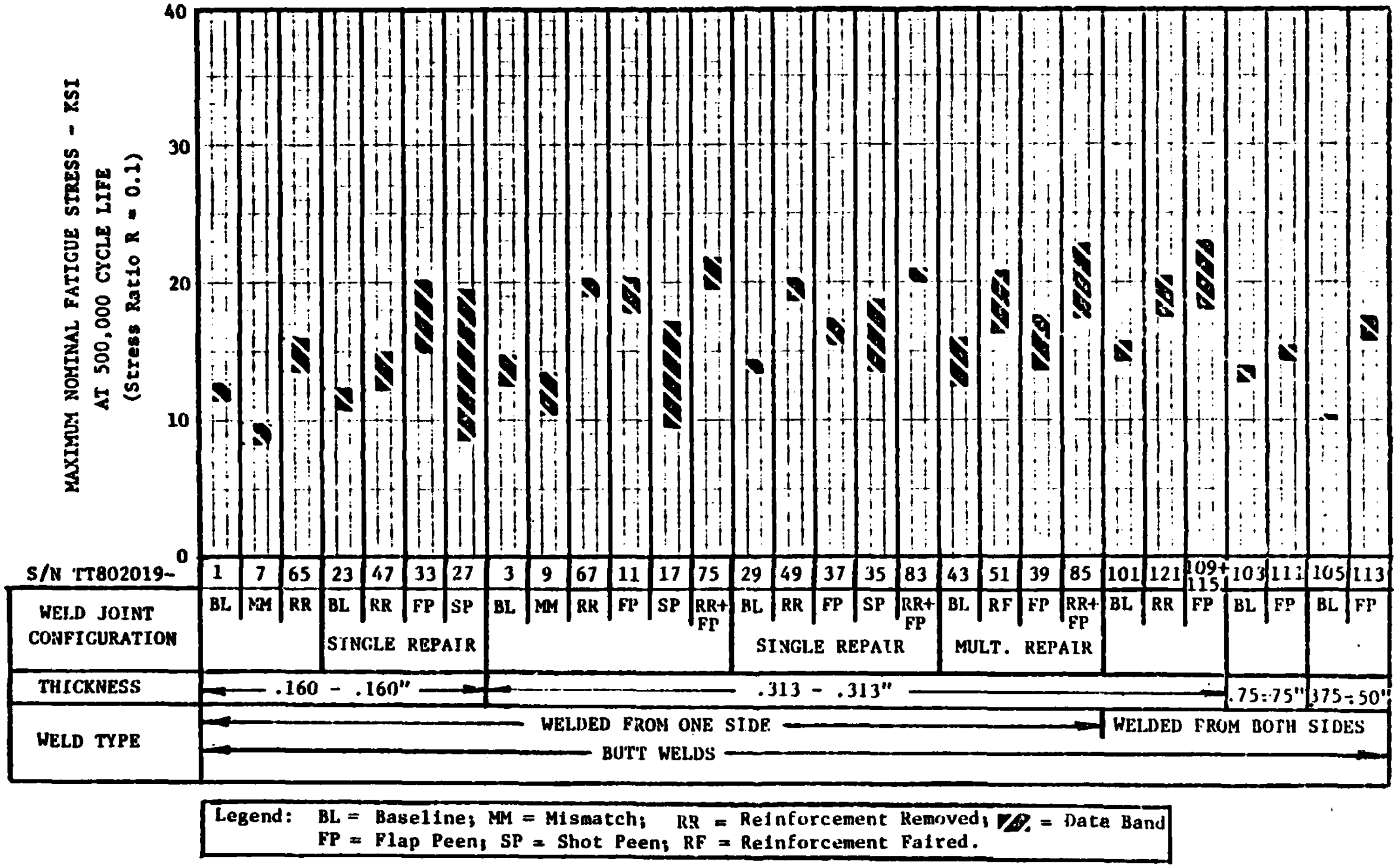
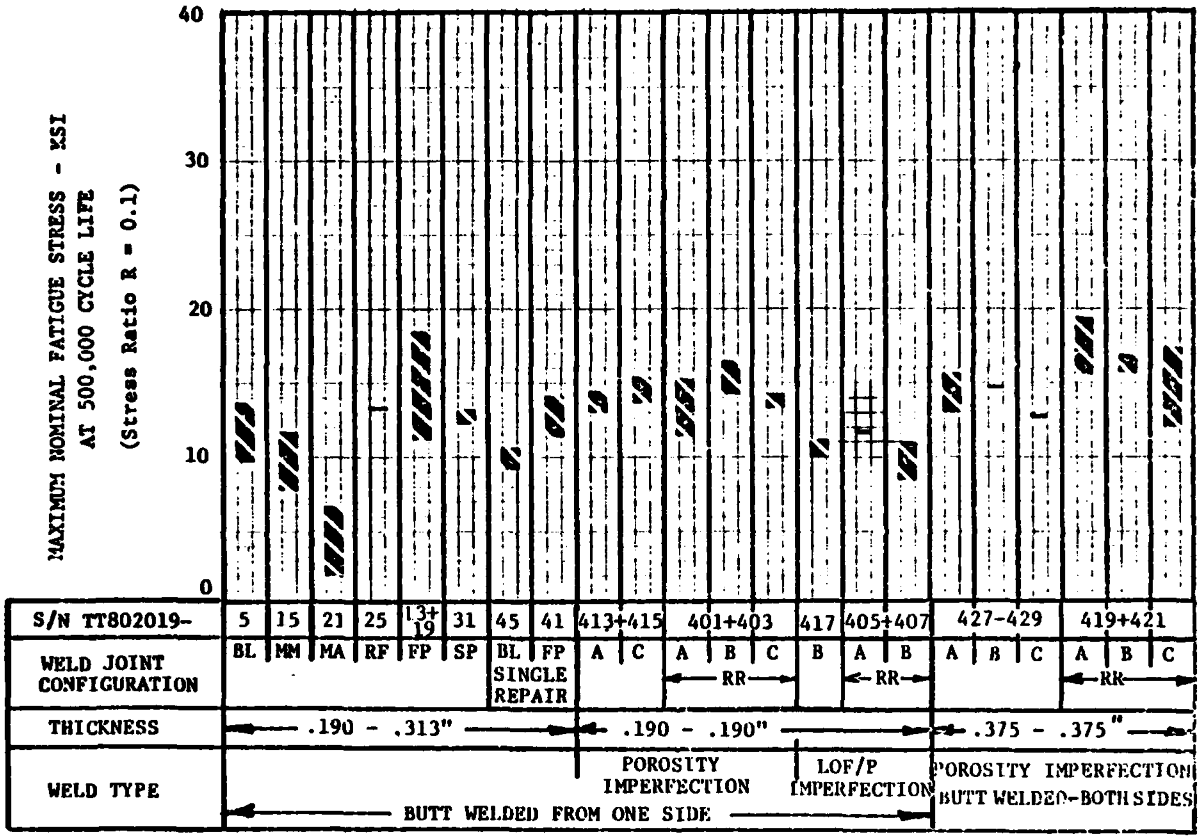
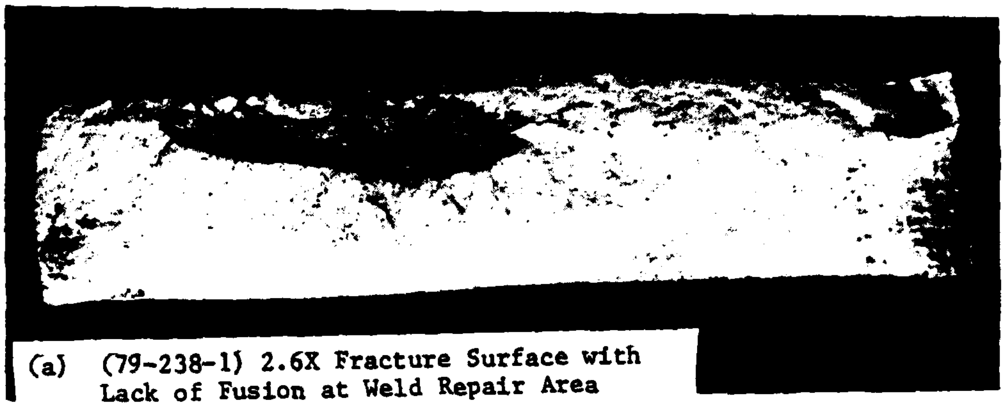


Figure 4-21. Summary of Butt Welded Plate Specimen Tensile Fatigue Strengths - Test Data Bands at 500,000 Cycles Endurance. (Sheet 1 of 2)



Legend: BL = Baseline; MM = Mismatch; MA = Misaligned; = Data Band.
RR = Reinforcement Removed, RF Reinforcement Faired,
FP = Flap Peen; SP = Shot Peen; LOF/P = Lack of Fusion/Penetration;
A, B, C = Porosity Imperfection Levels - A = 2.35 - 5.0%,
B = 5.01 - 7.5%, C = 7.51 + %; LOF/P Imperfection Levels -
A = .05 - .09 Inch Length, B = .125 - .20 Inch Length.

Figure 4-21. Summary of Butt Welded Plate Specimen Tensile Fatigue Strengths - Test Data Bands at 500,000 Cycles Endurance. (Sheet 2 of 2)



(a) (79-238-1) 2.6X Fracture Surface with Lack of Fusion at Weld Repair Area

(b) (79-238-2) 22X Cross-section Through Fracture Surface Showing Extent of Lock of Fusion

Figure 4-22. Multiply Weld Repaired Specimen (S/N TT802019-51,No.2) with Disqualifying Lock of Fusion

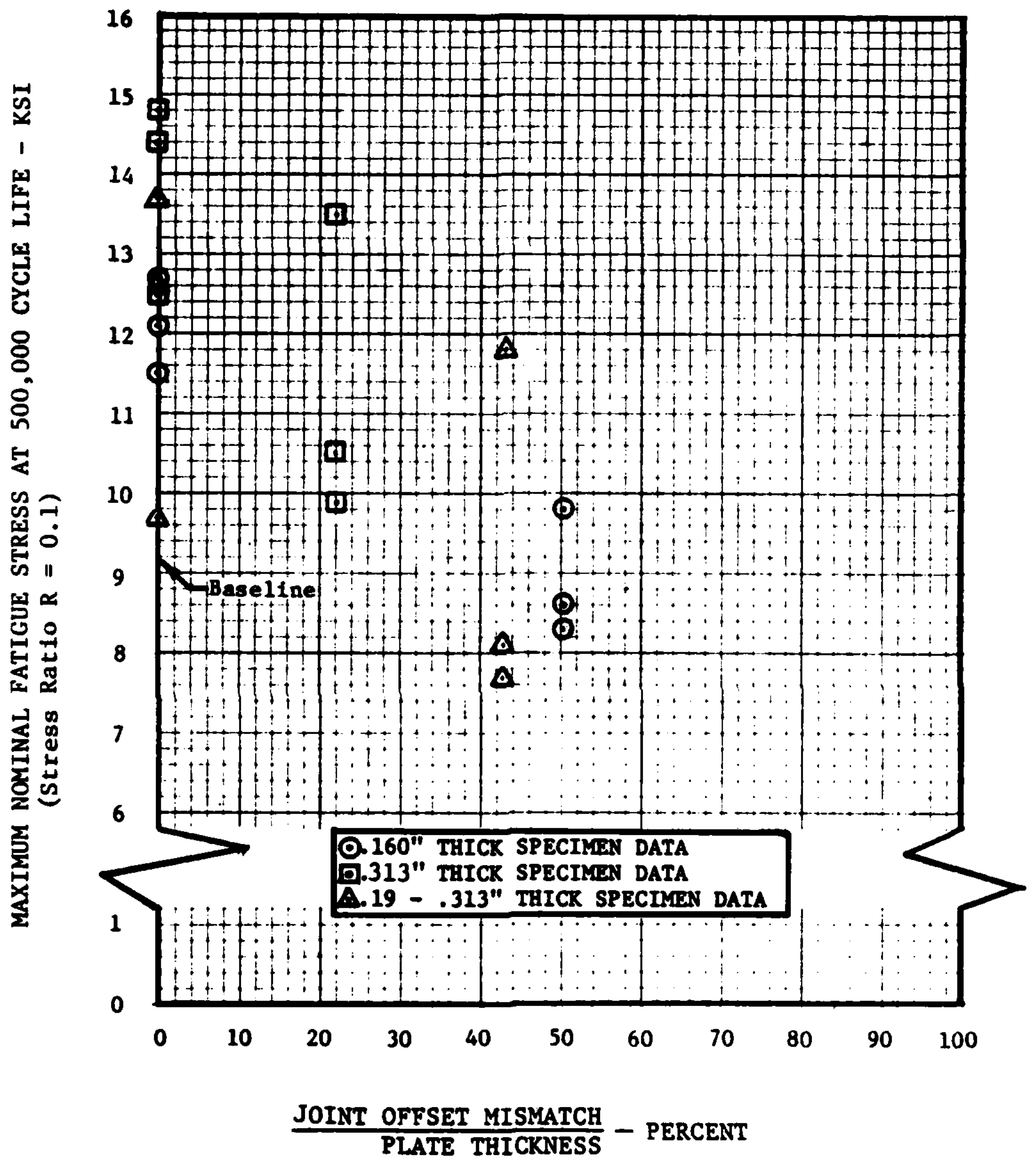


Figure 4-23. Effect of Joint Mismatch on Butt Welded Plate Specimen Tensile Fatigue Strength (for 500,000 Cycle Endurance).

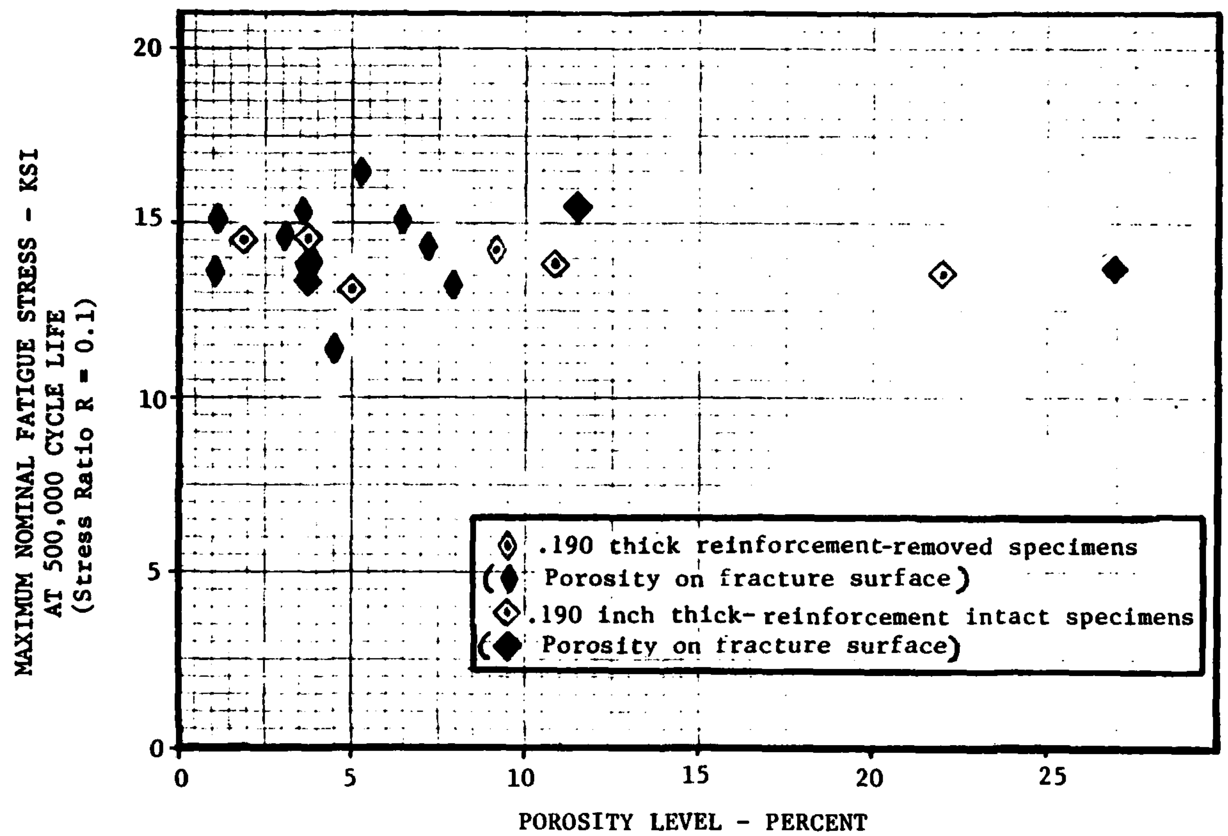


Figure 4-24. Effect of Porosity on 0.190 Inch Thick Butt Weld Specimen Fatigue Strength (for 500,000 Cycle Endurance).

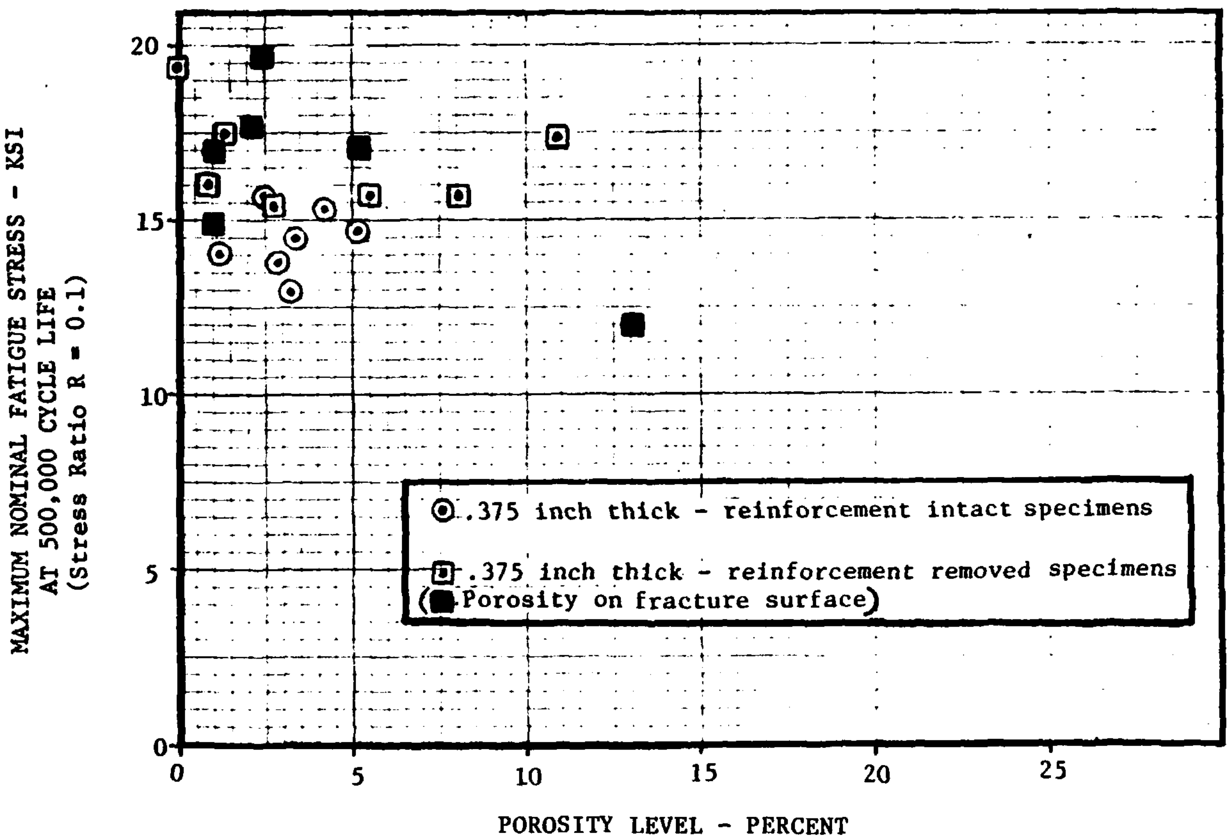
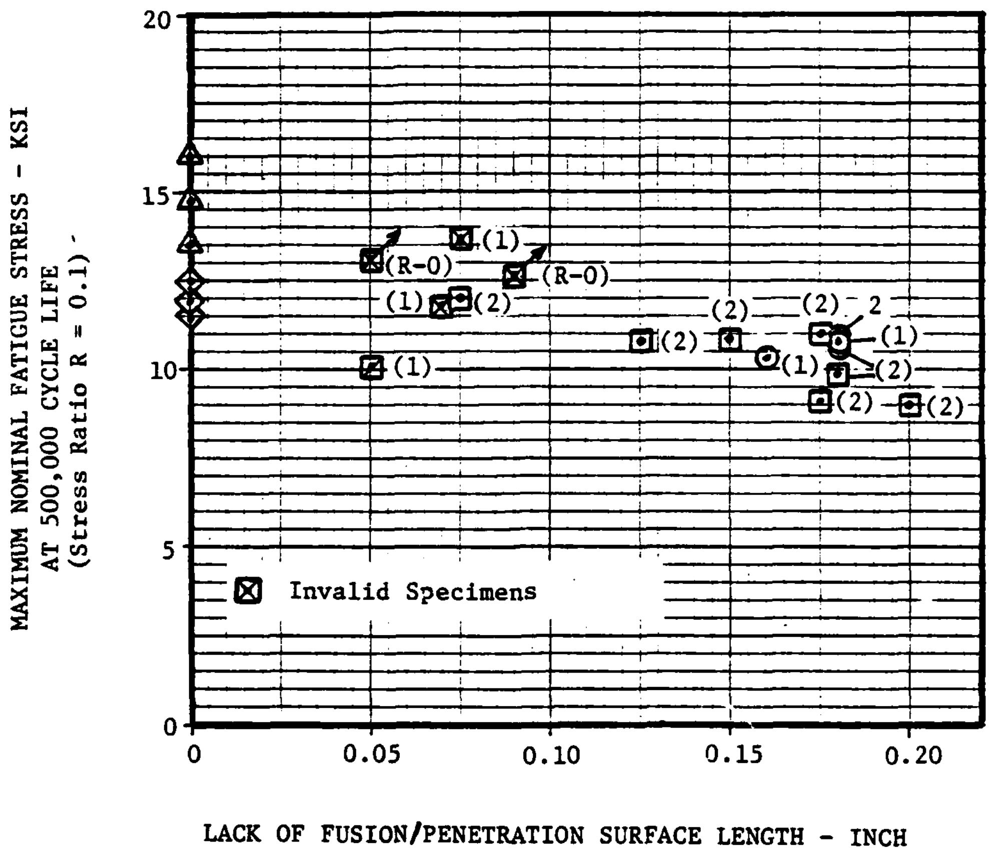


Figure 4-25. Effect of Porosity on 0.375 Inch Thick Butt Weld Specimen Fatigue Strength (for 500,000 Cycle Endurance).



(1) : Failure through weld toe
(2) : Failure through lack of fusion/penetration
⊙ : Reinforcement intact (TT802019-417) .190 - .190 inch thick
⊡ : Reinforcement removed (TT802019-405, 407).190 - .190 inch thick
△ : Reinforcement removed without LOF/P (TT80219-65).160 - .160 inch thick
◇ : Baseline specimens (TT802019-1).160 - .160 inch thick
R-0 : Run-out (no failure)

Figure 4-26. Effect of Lack of Fusion/Penetration Imperfections on Butt Weld Specimen Fatigue Strength (for 500,000 Cycle Endurance).

Test results for the lack of fushion/penetration (LOF/P) specimens indicate failure through the LOF/P to be prevalent at levels above 0.10 inch length. There was insufficient data to establish any strength differences between specimens with the reinforcement removed and those with the reinforcement intact. Specimens with 0.05 and 0.07 inch length LOF/P indications which failed through the weld toe were declared invalid when post-test examinations revealed the imperfections had been mechanically simulated by surface scribing; no actual LOF/P was evident.

Typical axial tension fatigue failure modes are shown in Figure 4-27 for rotary flapper peened and lack of fushion/penetration butt weld specimens as well as tee fillet and cruciform fillet weld specimens. Fatigue fracture surfaces of selected butt weld specimens are shown in Figure 4-28.

4.7.1.3 Bending Fatigue Results — Butt welded plate coupon bending fatigue tests results are presented as S-N envelopes in Figure 4-29. Bending fatigue strength comparisons based upon 500,000 cycle endurance, as presented in Table 4-8 and Figure 4-30, were determined using the S-N envelope boundary intercepts. In some cases, extrapolation beyond the data group was necessary.

The bending fatigue strength test results are only comparatively evaluated below due to the possibility of strain hardening effects on some specimens. This condition existed since bending fatigue stress levels which exceeded the published minimum, and in some cases, typical yield strength values were applied when necessary to precipitate failure within the one million cycle testing duration limit.

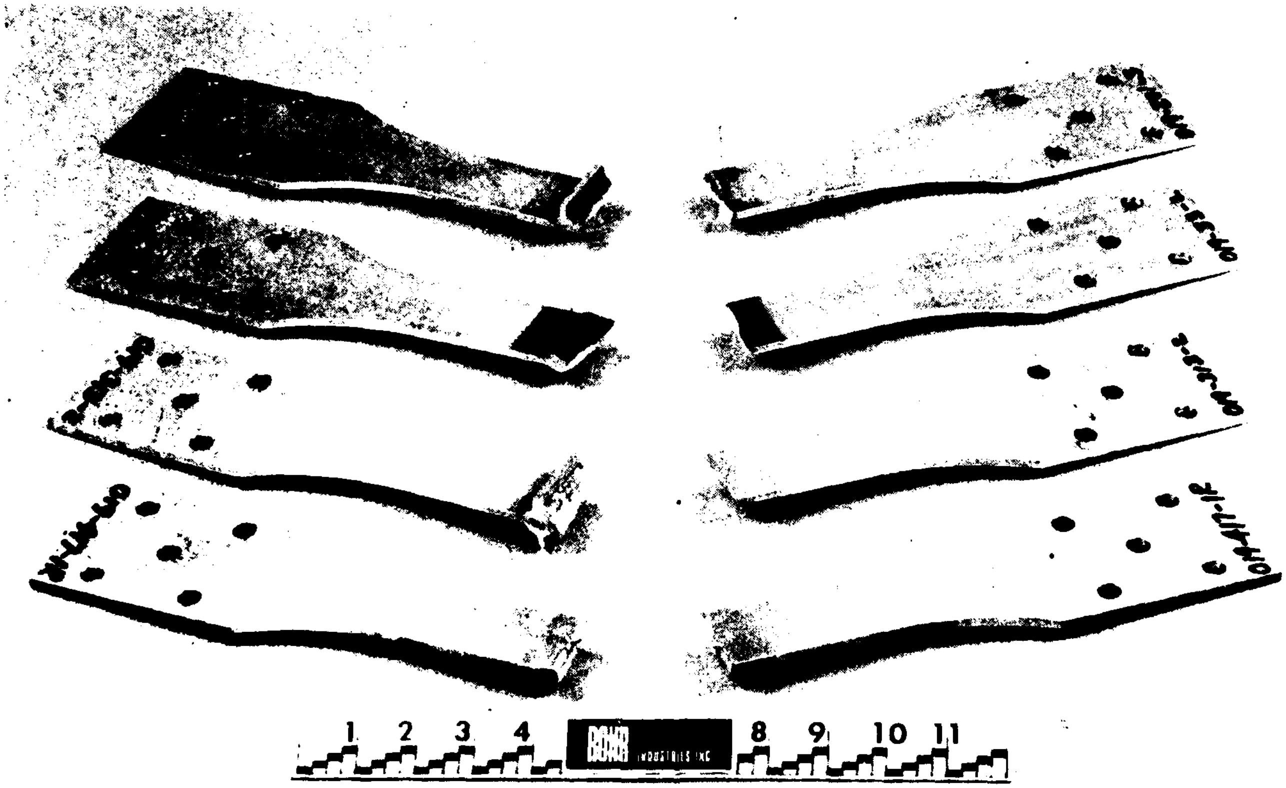


Figure 4-27. (790118-5) Typical Welded Plate Coupon Specimen Axial Fatigue Test Failure Modes. Top to bottom: Transverse Tee, Transverse Butt (TI/Flap Peened), Transverse Cruciform, Transverse Butt with LOP Imperfection.

(a) (790957-1)

(b) (750957-4)

Figure 4-28. Typical Butt Weld Axial Fatigue Specimen Fracture Surfaces

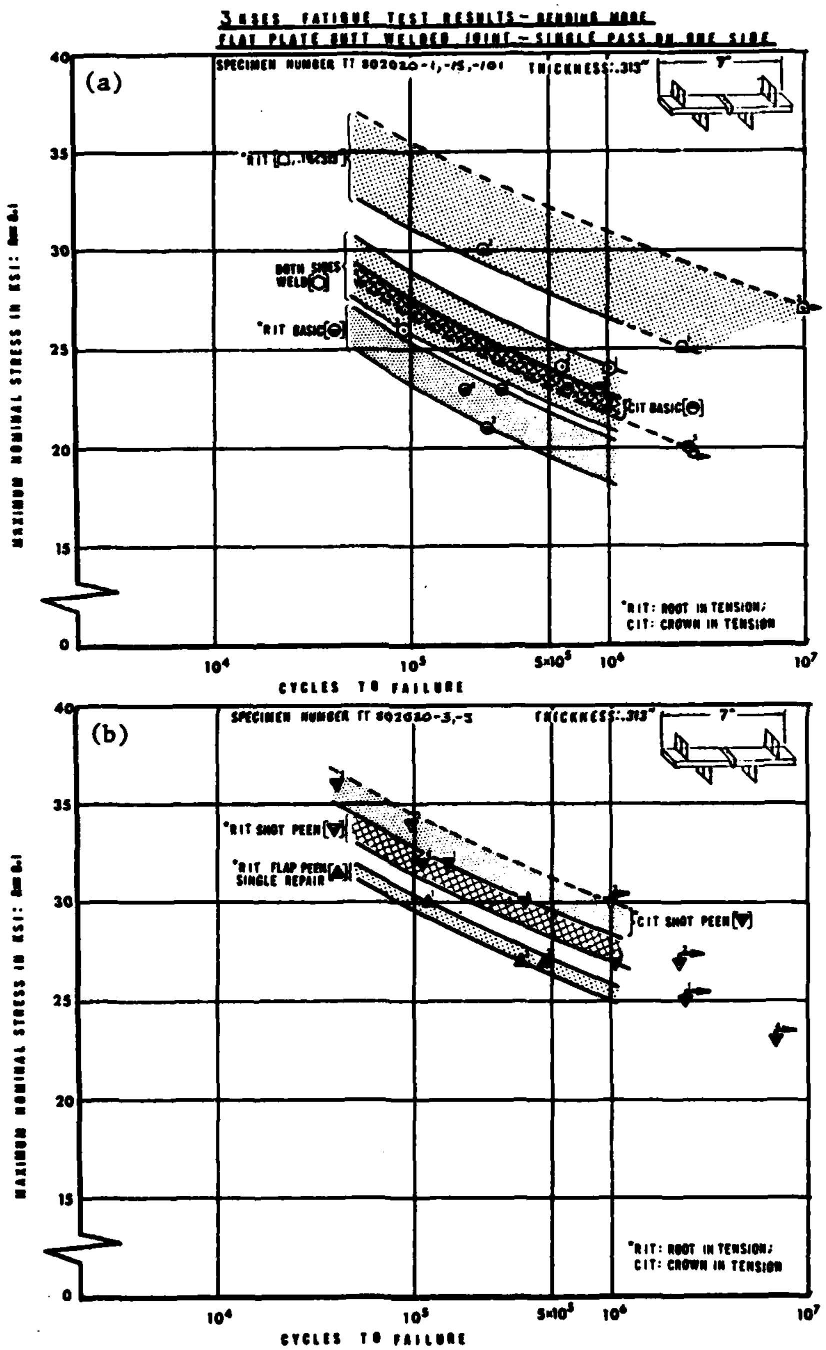


Figure 4-29. Butt Welded Plate Coupon Bending Fatigue Test Results (Sheet 1 of 2).

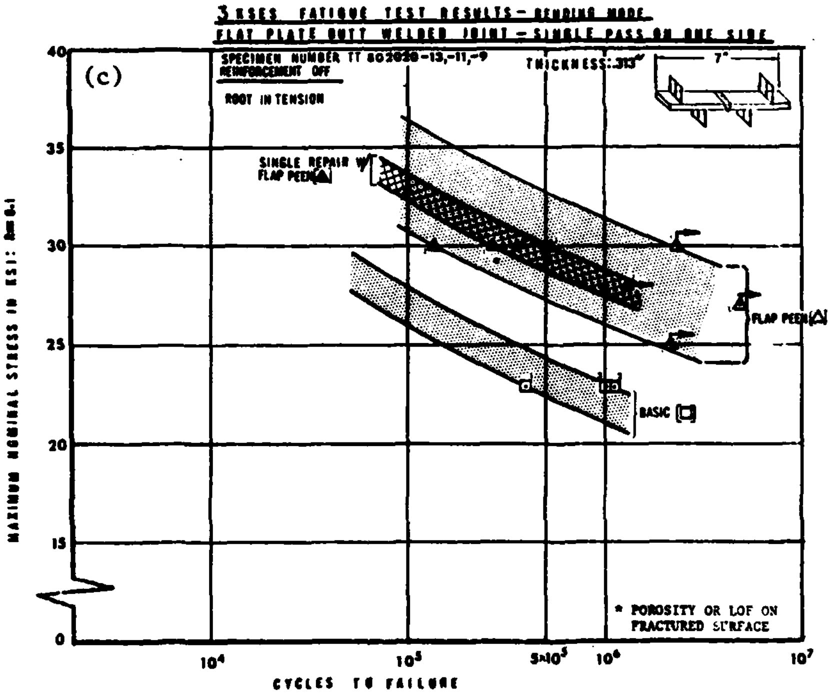
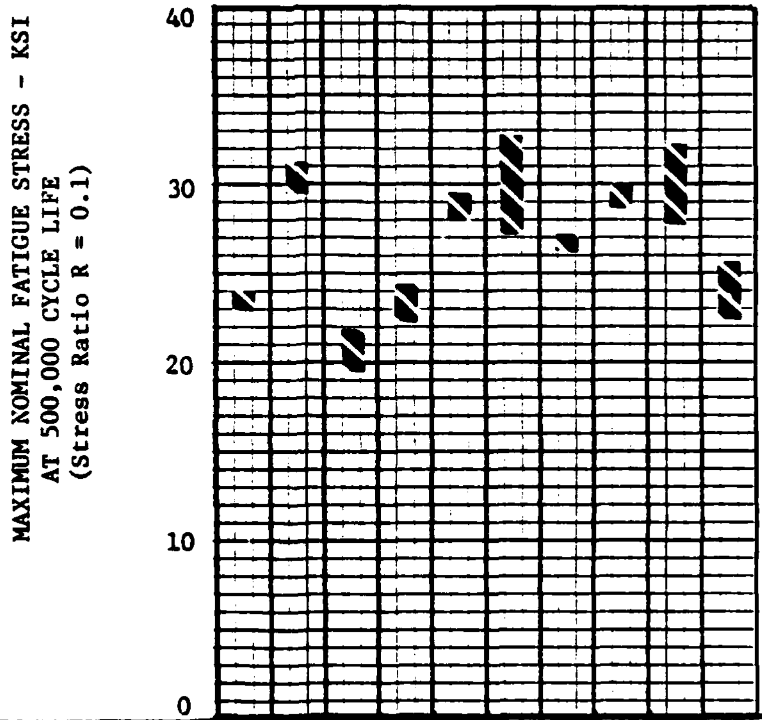


Figure 4-29. Butt Welded Plate Coupon Bending Fatigue Test Results (Sheet 2 of 2).

Table 4-8. Statistical Comparisons of Butt Welded Plate Specimen Bending Fatigue Strength.

SPECIMEN DESCRIPTION					STRENGTH AT 500,000 CYCLES MAXIMUM NOMINAL KSI; R = 0.1						FIG. NO.
TYPE WELD		Thk. Inch	Qty. Tested	Specimen Number	Low Strength	High Strength	Range	Average Strength	Std. Dev.	Avg-(3σ Dev.)	
				TT802020							
CIT* - BASIC	BUTT-SINGLE PASS -ONE SIDE	.313	3	-1	23	24	1.0	23.4	0.5	21.9	4-29(a)
CIT - SHOT PEEN			3	-3	29.5	31.2	1.7	30.5	0.7	28.4	4-29(b)
RIT* - BASIC			3	-1	19.5	21.8	2.3	20.8	1.2	17.2	4-29(a)
RIT - *REINF. REMOVED*			3	-9	22.3	24.3	2.0	23.6	1.2	20.0	4-29(c)
RIT - SHOT PEEN			3	-3	28	29.5	1.5	28.8	0.8	26.4	4-29(b)
RIT - REINF. REMOVED & FLAP PEEN			3	-11	27.2	32.7	5.5	30.3	2.8	21.9	4-29(c)
RIT - SINGLE REPAIR-FLAP PN.			3	-5	26.3	27.2	0.9	26.8	0.5	25.3	4-29(b)
RIT - SINGLE REPAIR-FLAP PN. - REINF. REMOVED			3	-13	28.7	30.0	1.3	29.5	0.7	27.4	4-29(c)
RIT - BASIC - BUTT		.190									
WELDED BOTH SIDES		.313	3	-15	27.8	32.2	4.4	29.5	2.4	22.3	4-29(a)
		.313	3	-101	22.3	25.5	3.2	24.0	1.6	19.2	4-29(a)

*Bending Direction: CIT = Weld Crown in Tension; RIT - Weld Root in Tension.



S/N TT 802020-	1	3	1	9	3	11	5	13	15	101
WELD JOINT CONFIGURATION	CIT BL	CIT SP	RIT BL	RIT RR	RIT SP	RIT RR+ FP	RIT FP SINGLE REPAIR	RIT RR+FP	RIT	BL
THICKNESS(Inch)	← .313 - .313" →								.19/ .313	.313"
WELD TYPE	← WELDED FROM ONE SIDE →									WELDED BOTH SIDES
	← BUTT WELDS →									

Legend: BL = Baseline; RR = Reinforcement Removed; FP = Flap Peen; ▨=Data Band; SP=Shot Peen; CIT = Crown In Tension; RIT = Root in Tension.

Figure 4-30. Summary of Butt Welded Plate Specimen Bending Fatigue Strengths - Test Data Bands at 500,000 Cycles Endurance.

Table 4-9. Cruciform Plate Specimen Fillet Weld Transverse Shear Static Test Results.

SPECIMEN NO.	NOMINAL SIZE		TEST SECTION DIMENSIONS				TEST RESULTS			
	PLATE THICK (inch)	FILLET SIZE (inch)	Width (inch)	Thick (inch)	Area (in.^{2})	Avg. Fillet Size (inch)	ULTIMATE LOAD (lb.)	DOUBLE FILLET ULTIMATE STRENGTH (lb./linear in.)	FAILURE LOCATION	ULT.* STRESS (KSI)
TT802016-201-1	.180	1/8	1.506	.183	.276	.158	11,750	7,800	Through Fillets	42.6
-2	.180	1/8	1.506	.184	.277	.145	11,750	7,800		42.4
-3	.180	1/8	1.502	.184	.276	.165	11,900	7,925		43.1
-205-1	.500	3/8	1.509	.505	.762	.370	29,300	19,430		38.5
-2	.500	3/8	1.499	.505	.757	.373	30,200	20,145		39.9
-3	.500	3/8	1.505	.505	.760	.340	29,700	19,735		39.1
-209-1	.750	5/8	1.510	.760	1.148	.618	51,400	34,040		44.8
-2	.750	5/8	1.506	.760	1.145	.590	53,300	35,395		46.6
-3	.750	5/8	1.511	.759	1.147	.593	52,450	34,710		45.7

*Stress based on parent metal cross section area.

Separate groups of bending fatigue specimens were tested with the weld crown (side from which weld was made) in tension and the weld root in tension. Results from the crown-in-tension tests on welds made single pass from one side indicated the following: higher strength than root-in-tension; equivalent strength to welded from both sides; and substantial strength improvement with shot peening.

The bending fatigue results from specimens tested with the weld root-in-tension indicated that the baseline strength was improved by all post-weld processes which included weld reinforcement removal, shot peening, rotary flapper peening, and reinforcement removal with flapper peening. Equivalent root-in-tension strength was demonstrated between single repair reinforcement-removed with flap peening and unrepaired reinforcement-removed with flap peening.

The sole failure mode for the bending fatigue specimens with the root reinforcement intact was at the weld toe with multiple origins as shown in Figure 4-31. Toe failures were also encountered in all but two of the reinforcement-removed specimens where the remaining reinforcement height was typically between 0.010 and 0.025 inch. In one of the two exceptions, failure occurred through the parent material heat affected zone. In the second case, failure initiated through a surface gouge in the parent material approximately one-half inch from the weld toe.

4.7.2 FILLET WELDED SPECIMENS

4.7.2.1 Static Tensile Results — Fillet welded transverse cruciform specimen static tension test results are tabulated in Table 4-9 in terms of ultimate load per unit length of double fillet weld. This unit strength as a function of fillet size is plotted in Figure 4-32 and is comparable with typical American Welding Society results as shown.

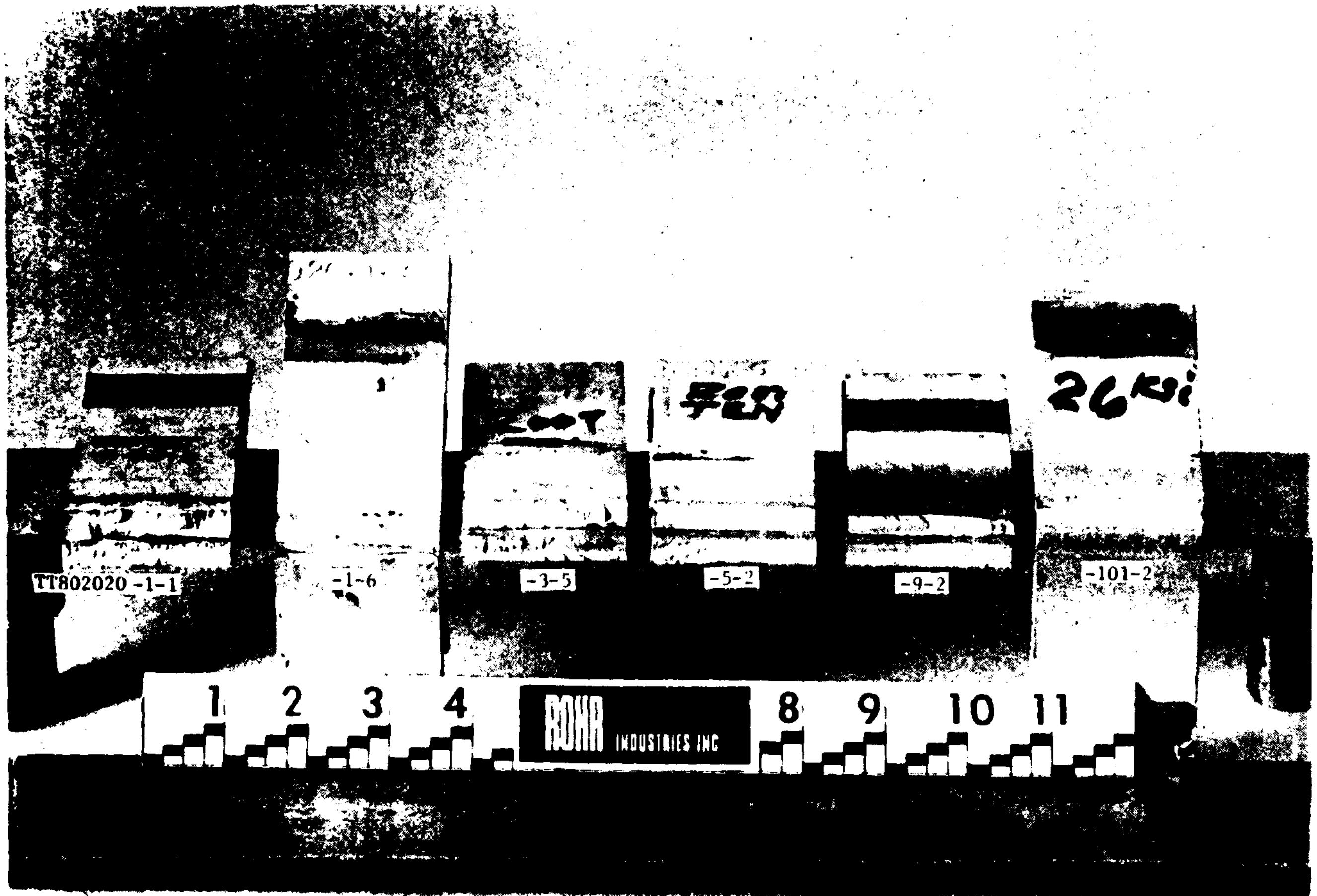


Figure 4-31. (790957-5) Typical Butt Weld Bending Fatigue Specimen Failures Showing Fracture Surface Details

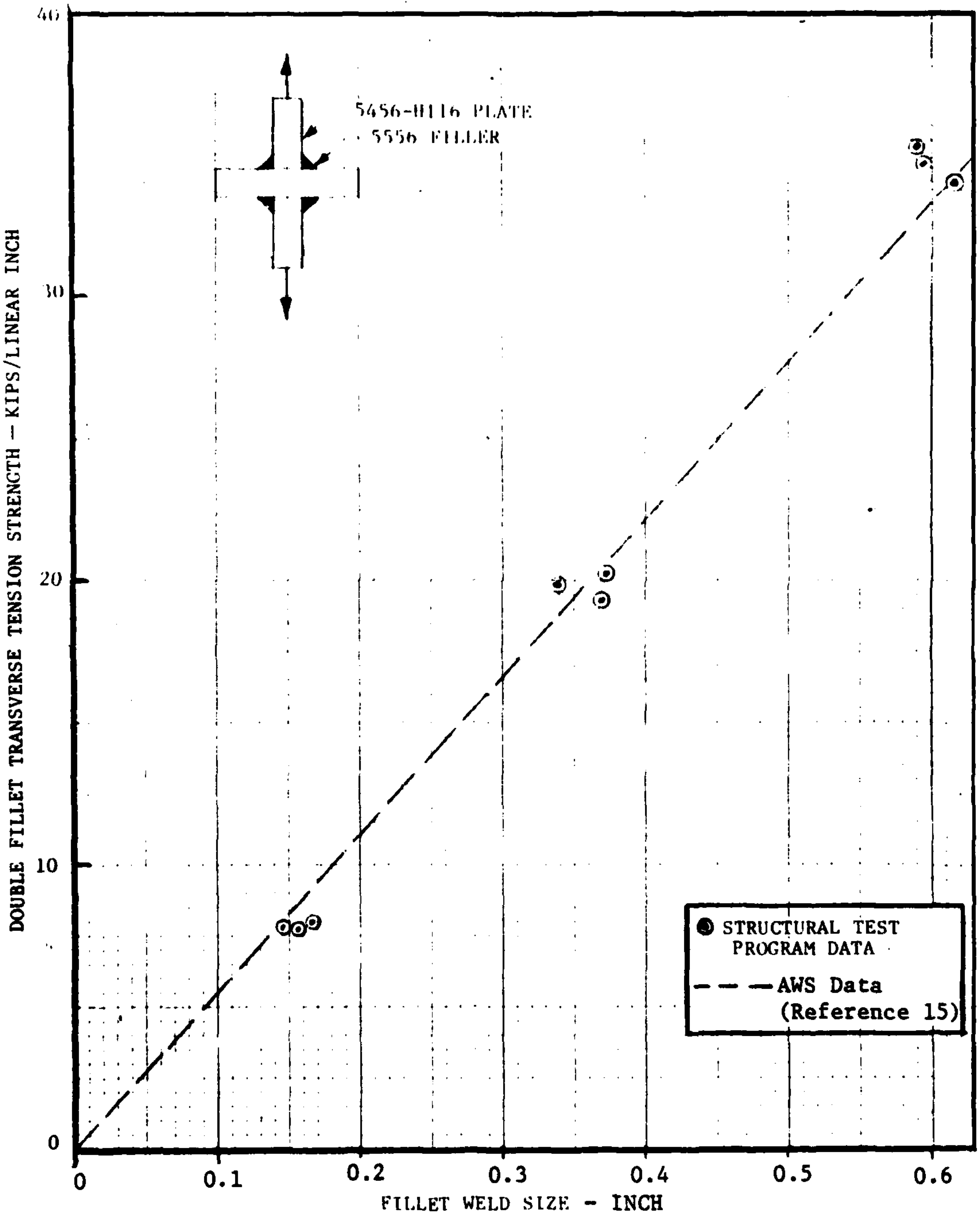


Figure 4-32. Correlation of Fillet Weld Transverse Shear Ultimate Strength Test Results with Published Data.

The static failure mode was transverse shear fracture through both fillets as shown previously in Figure 4-18.

4.7.2.2 Tensile Fatigue Results — Axial tensile fatigue test results from the fillet welded transverse cruciform and transverse tee specimens are presented in Figures 4-33 and 4-34, respectively. Individual test data points as well as an S-N envelope are shown for each specimen type. Parent metal maximum nominal stress, rather than fillet strength, was selected as the independent variable for the S-N curves since the predominant fatigue failure mode was through the heat affected zone of the parent material. The S-N envelopes in Figures 4-33 and 4-34 were defined by theoretically derived S-N curves as explained for the butt weld fatigue results in Section 4.7.1.2 above.

Tensile fatigue strength comparisons at 500,000 cycle endurance, as presented in Table 4-10 and Figure 4-35, were determined using the S-N envelope boundary curve intercepts. In some cases, extrapolation beyond the data group life limits was necessary.

Transverse cruciform fillet weld specimen fatigue strength was found to be affected by the following factors:

a. Thickness: The thinner (0.160 inch thick) specimens demonstrated higher fatigue strength than the 0.281 inch thick specimens, which was especially evident for convex weld reinforcement contours. This apparently was due to the relatively greater weld root penetration on the thinner specimens as indicated from examination of the fracture surfaces. Also, when the depth of root penetration was not a factor, i.e., the full penetration welded specimens, fatigue strength of the 0.281 inch thick specimens was higher.

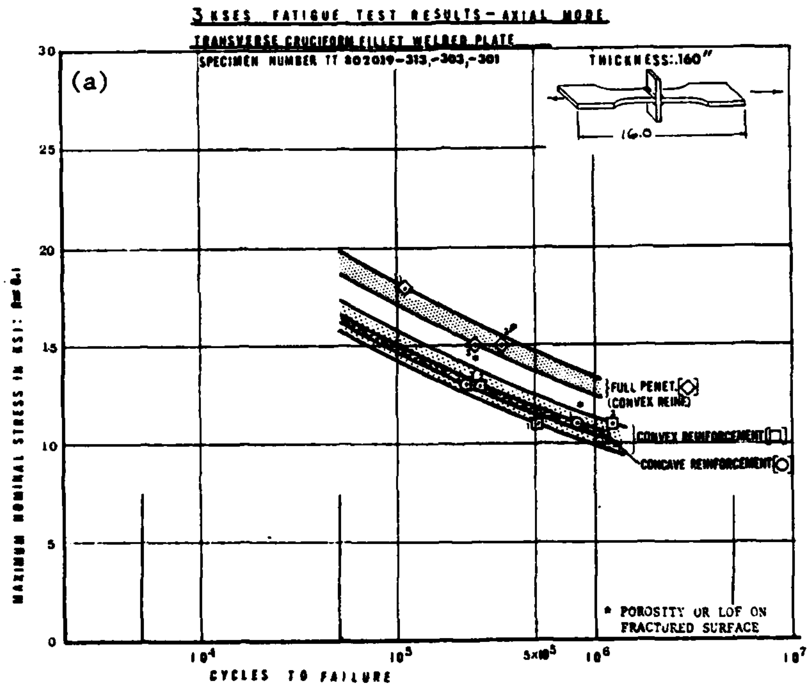


Figure 4-33. Fillet Welded Plate Transverse Cruciform Specimen Axial Tension Fatigue Test Results. (Sheet 1 of 2)

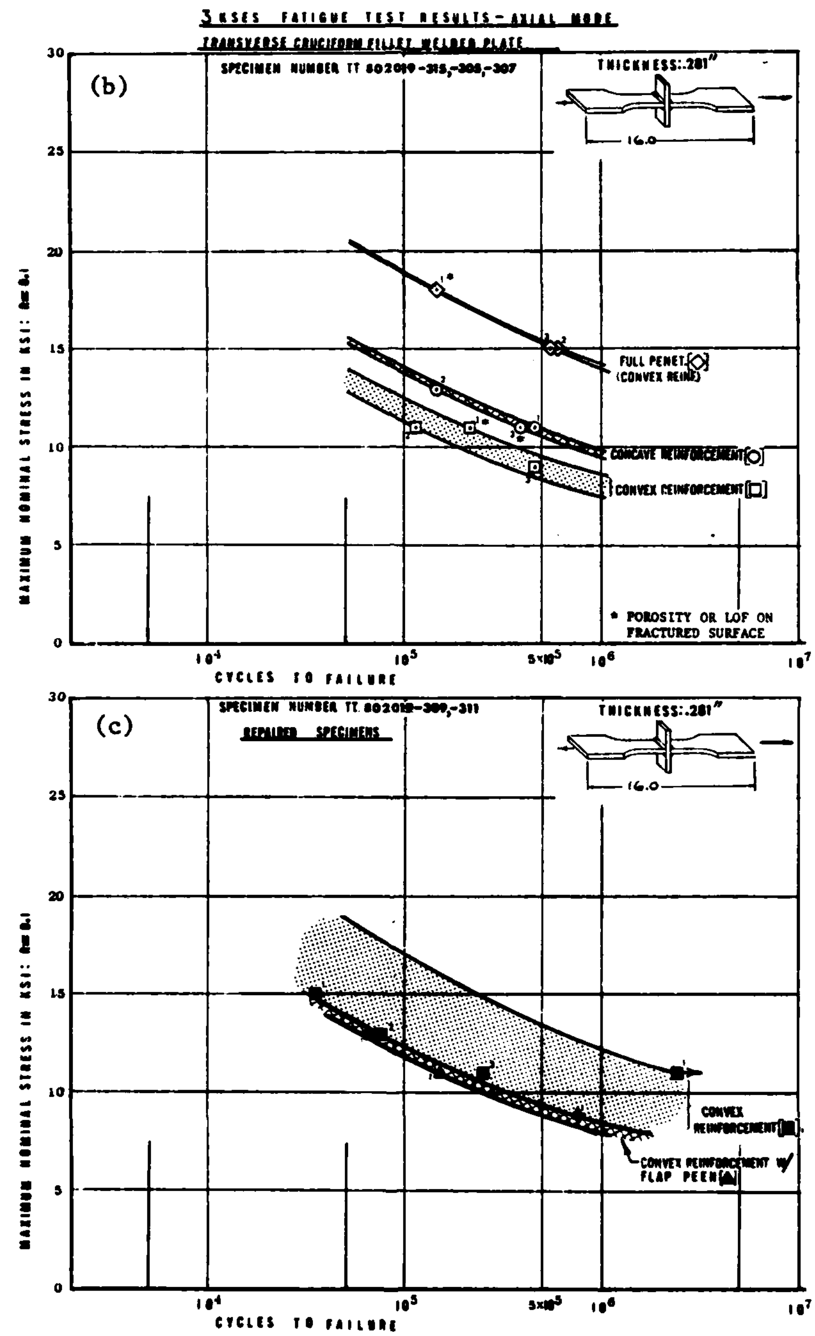


Figure 4-33. Fillet Welded Plate Transverse Cruciform Specimen Axial Tension Fatigue Test Results.(Sheet 2 of 2)

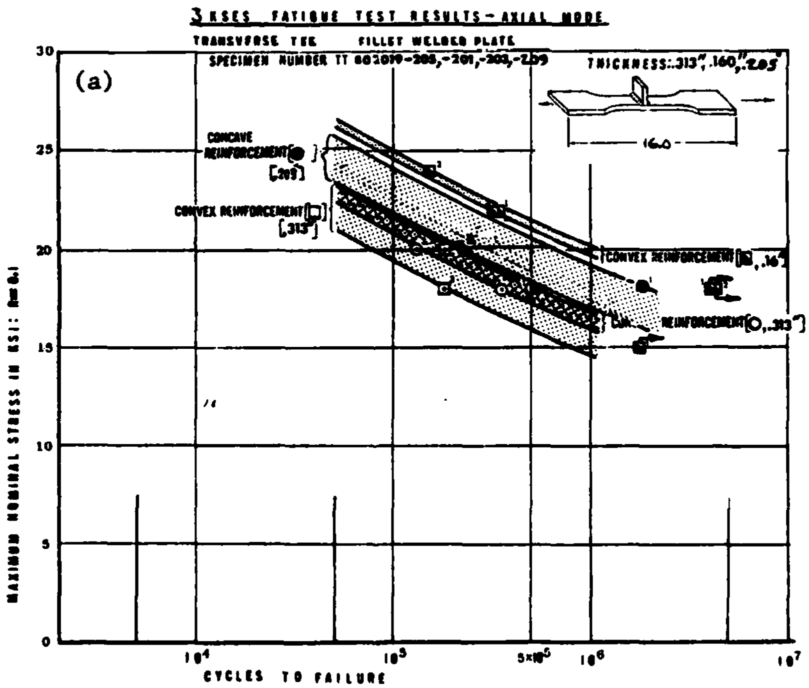
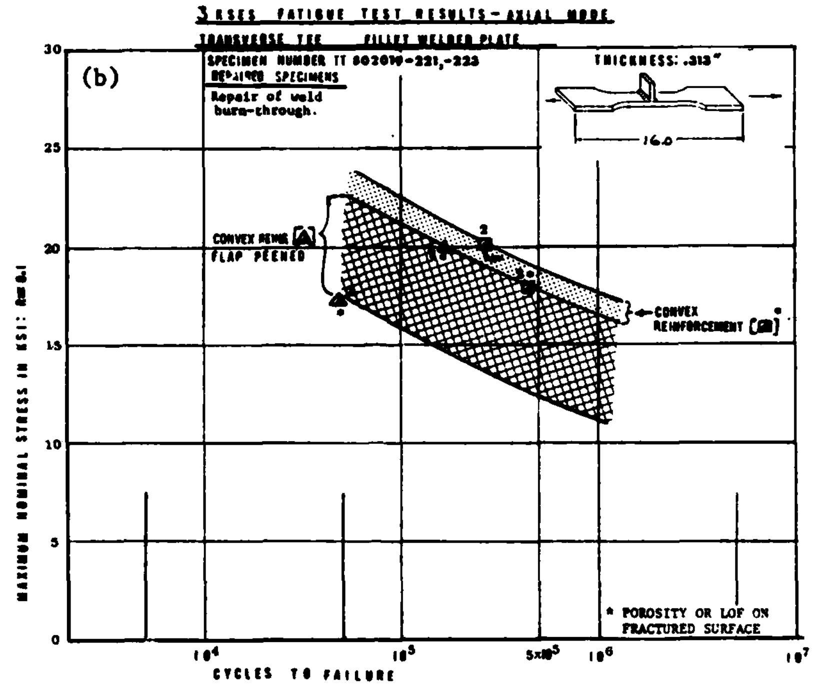


Figure 4-34. Fillet Welded Plate Transverse Tee Specimen Axial Tension Fatigue Test Results. (Sheet 1 of 2)



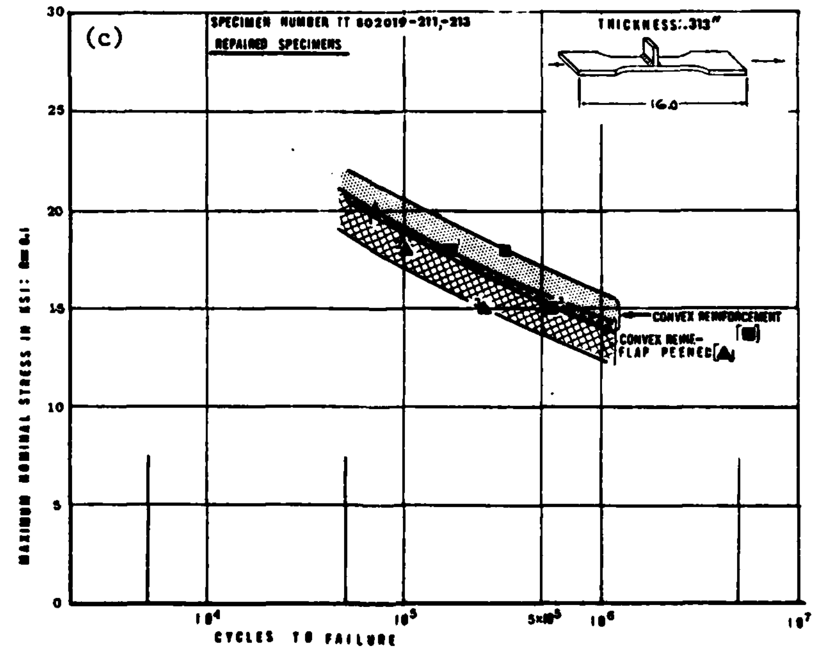


Figure 4-34. Fillet Welded Plate Transverse Tee Specimen Axial Tension Fatigue Test Results. (Sheet 2 of 2)

Table 4-10. Statistical Comparisons of Fillet Welded Transverse Cruciform and Transverse Tee Specimen Tensile Fatigue Strength.

SPECIMEN DESCRIPTION				STRENGTH AT 500,000 CYCLES MAXIMUM NOMINAL KSI; R = 0.1						FIG. NO.
TYPE WELD	Thk. (Inch)	Qty. Tested	Specimen Number	Low Strength	High Strength	Range	Average Strength	Std. Dev.	Avg.-(3σ Dev.)	
TRANSVERSE CRUCIFORM - CONVEX	.160	3	TT802019 -303	11.2	12.5	1.3	11.8	0.7	9.7	4-33(a)
CONCAVE		3	-301	11.5	11.8	0.3	11.6	0.2	11.0	4-33(a)
CONVEX - FULL PENET.		3	-313	13.5	14.7	1.2	14.1	0.6	12.3	4-33(a)
CONVEX	.281	3	-307	8.3	9.5	1.2	8.9	0.6	7.1	4-33(b)
CONCAVE		3	-305	10.5	10.8	0.3	10.6	0.2	10.0	4-33(b)
CONVEX - FULL PENET.		3	-315	15.3	15.4	0.1	15.3	0.1	15.0	4-33(b)
REPAIRED CONVEX		3	-309	9.3	13.5	4.2	10.6	2.0	4.6	4-33(c)
REPAIRED CONVEX & FLAP PEEN		3	-311	8.8	9.4	0.6	9.1	0.3	8.2	4-33(c)
TRANSVERSE TEE - CONVEX	.160	3	-201	21	21.5	0.5	21.2	0.3	20.3	4-34(a)
CONVEX	.313	3	-205	15.9	18.3	2.4	17.3	1.2	13.7	4-34(a)
CONCAVE		3	-203	17.0	18.3	1.3	17.5	0.7	15.4	4-34(a)
REPAIRED - CONVEX		3	-211	15.3	17.2	1.9	16.1	1.0	13.1	4-34(c)
REPAIRED - CONVEX (BURN THRU.)		2	-221	17.6	19	1.4	18.3	1.0	15.3	4-34(b)
REPAIRED CONVEX FLAP PEEN		3	-213	13.7	15.8	2.1	14.7	1.1	11.4	4-34(c)
REPAIRED CONVEX FLAP PEEN (BURN THRU.)		2	-223	12.3	17.5	5.2	14.9	3.7	3.9	4-34(b)
CONCAVE	.205	3	-209	18.2	20.5	2.3	19.2	1.2	15.6	4-34(a)

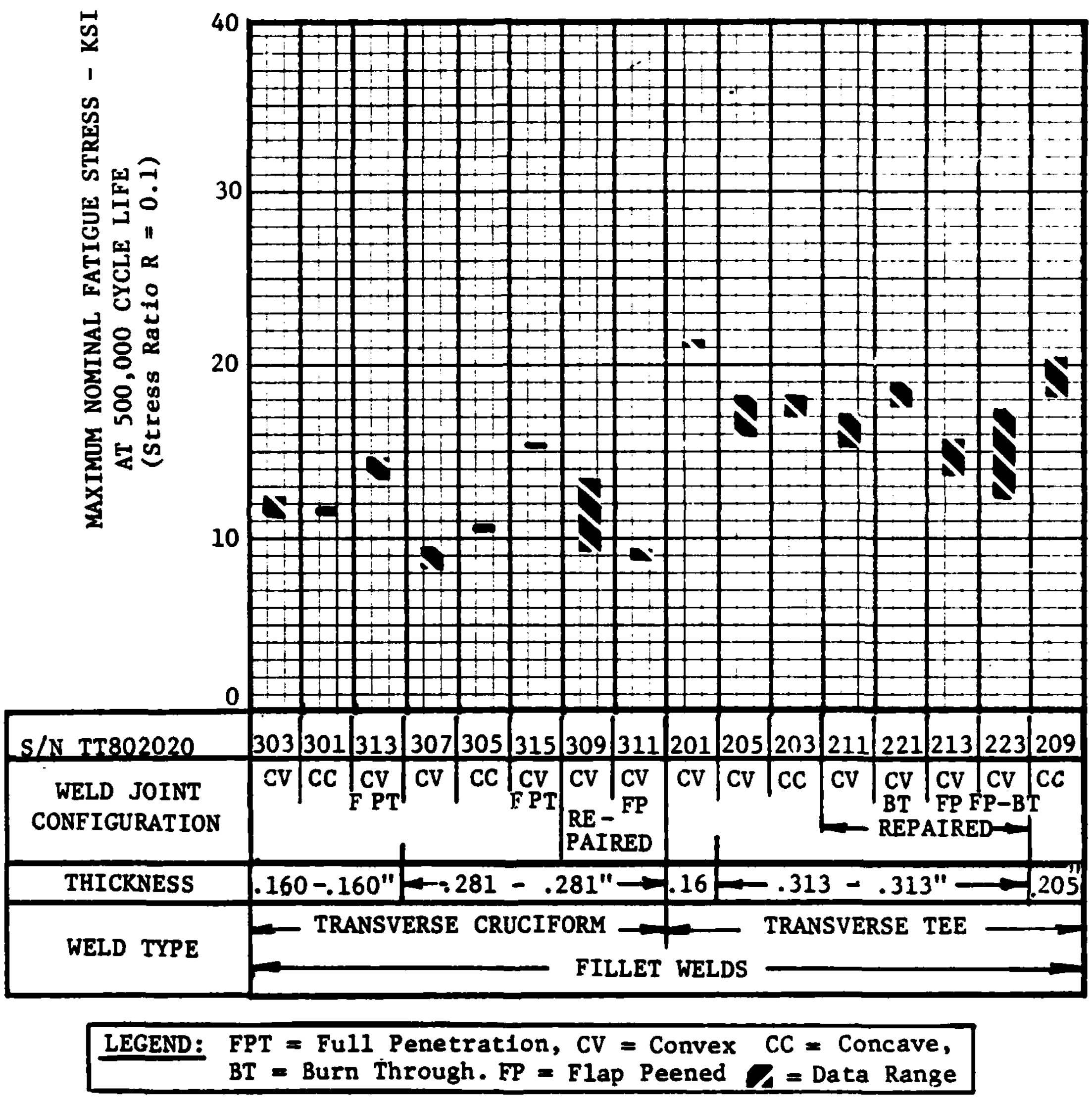


Figure 4-35. Summary of Transverse Fillet Welded Plate Specimen Axial Fatigue Strengths - Test Data Bands at 500,000 Cycles Endurance.

Figure 4-36. (790957-2) Typical Transverse Fillet Weld Axial Fatigue Specimen Failures Showing Fracture Surface Details

b. Weld Type: Fillet welds with convex reinforcement contours had equivalent strength to concave contoured welds for the 0.160 inch thick material but lower strength for the 0.281 inch thickness. Convex contour full penetration welds produced significantly higher strengths than convex contour fillet welds with minimal weld root penetration.

c. Weld Repairs: Repairs to the fillet welds on the 0.281 inch thick specimens did not adversely affect the evelope lower boundary strength for convex contour welds. Weld repair data was not obtained for concave contour welds.

d. Post Weld Processing: Flap peening on repaired convex contour welds did not improve fatigue strength.

The two transverse cruciform fatigue failure modes observed during testing were failures through the fillets with origins at the weld roots, and failures through the heat affected zone of the axially loaded parent metal with origins at the fillet toe. The type of mode for each specimen appeared random in occurence with the exception of the six full penetration specimens. Five of these specimens exhibited the failure mode through the parent metal. Typical fillet weld cruciform specimen fatigue failure fracture surfaces are illustrated in Figure 4-36.

The fatigue strength of fillet welded transverse tee specimens was affected by the following factors:

a. Thickness: As in the cruciform specimens, the thinner (0.160 inch thick) tee configuration demonstrated greater strength than the thicker material (0.313 inch thick) configuration with convex contour fillet welds on both. The 0.205 inch thick concave weld contour specimens also exhibited a strength level greater than the 0.313 inch thick specimens. As before, this behavior is attributed to the relatively larger degree of weld root penetration occurring on the thinner materials.

b. Weld Type: Concave contour transverse tee fillet welds demonstrated increased lower envelope strength over convex weld contour welds on 0.313 inch thick material.

c. Weld Repairs: Repairs of defective fillet weld areas and repairs of weld burn-throughs were evaluated for welds in 0.313 inch thick material and produced nominal strength decrease and increase, respectively, compared to the basic convex contour welds without repairs.

d. Post-Weld Processing: Flapper peening weld processing was only performed on specimens containing weld repairs. In both normal and burn-through repairs, flapper peening caused strength reductions.

The single failure mode observed for the fillet welded transverse tee specimens was failure through the heat affected zone of the axially loaded parent metal with origins at the toe of the fillet weld. Typical failed specimens are shown in Figure 4-36 with exposed fracture surfaces.

4.8 CONCLUSIONS

The conclusions summarized below are based upon the above test results and are applicable to the specific weldments and tests as delineated in this report. Unless otherwise stated, all conclusions are based on welds made single pass from one side with nominal joint fit-up tolerances.

4.8.1 BUTT WELDS

4.8.1.1 Axial Strength —

a. Butt weld static tensile strengths meet or exceed both the 3KSES yield and ultimate design strengths with the following exceptions: Offset mismatch joint welds between materials of the same or different thicknesses welded from one or both

sides; reinforcement-removed welds in 0.190 inch thick material with weld porosity greater than 4 percent; and welds with lack of fusion/penetration indications with the weld reinforcement intact or removed.

b. Butt welds made from one side in 0.313 thick material exhibit more than eight percent increase in fatigue strength over welds made from one side in 0.160 inch thick material.

c. Butt welds between plates of different thicknesses exhibit: static strength which exceeds the 3KSES design allowables; lower fatigue strength than welds joining plates of the same thickness; static and fatigue strengths which are adversely affected by joint offset mismatch, and fatigue strength adversely affected by joint angular misalignment.

d. Butt welds made from both sides exhibit 11 percent higher static and 15 percent higher fatigue tensile strength than welds made from one side.

e. Single and multiple repaired welds (repairs made with gas tungsten arc welding) do not degrade static or fatigue strength when accomplished by proper weld procedures.

f. Butt welds joining plates nominally mismatched between 1/16 and 1/8 inch substantially reduce static and fatigue tensile strength.

g. Welding of joints which are angularly misaligned five degrees can cause a severe reduction in fatigue strength of joints between materials of different thicknesses, and a nominal static strength reduction for joints between materials of the same thickness.

h. A significant increase in butt weld fatigue strength can be obtained by post-weld processing consisting of reinforcement removal (see below), reinforcement contour fairing, rotary flapper (or brush) peening with reinforcement fairing, and reinforcement removal with flapper peening. The greatest

strength improvement was attained by reinforcement removal with flapper peening.

i. Butt weld reinforcement removal, in addition to fatigue strength improvement, produces a nominal static strength reduction, and marginally improves fatigue strength of welds containing porosity imperfections. Reinforcement removal from butt welds containing porosity induces porosity failure modes compared to weld toe failures in welds with the reinforcement left intact.

j. Air blast shot peening is not a reliable post-weld process for improving fatigue strength.

k. Porosity levels in butt welds up to 1.8 percent with the weld reinforcement left intact, do not affect static tensile strength. Porosity levels above four percent with the weld reinforcement removed, reduces static tensile strength to levels below the 3KSES ultimate tensile strength design allowables.

Butt welds with porosity levels up to 5 percent (and possibly higher) with the weld reinforcement intact, develop equivalent fatigue strength to comparable welds without porosity. Porosity at levels above one percent in welds with the reinforecement removed substantially reduces the fatigue strength compared to equivalent welds without porosity.

Butt welds with porosity levels ranging up to 10 percent exhibit a relatively constant fatigue strength with substantial scatter.

l. Lack of fushion/penetration imperfections in butt welds significantly degrade the static tensile strength to levels below the 3KSES ultimate tensile strength design allowables. Lack of fusion/penetration imperfections with sufficiently small surface lengths to be accpetable could not be produced.

Lack of fushion/penetration imperfections also significantly reduce butt weld fatigue strength which tends to vary inversely with the surface length of the imperfection.

4.8.1.2 Bending Fatigue Strength —

a. Butt welds are more critical in axial tension fatigue by a substantial margin compared to uni-direction bending fatigue.

b. In butt welds made from one side, the root is fatigue critical in comparison to the weld crown (side from which weld was made). This condition can be alleviated by welding joints from both sides.

c. Bending fatigue strength is significantly improved by shot peening and to a lesser extent by weld reinforcement removal or reinforcement removal with flapper peening.

d. Flapper peened single repair butt welds, with the reinforcement either intact for removed, exhibit bending fatigue strengths comparable to welds without repairs.

4.8.2 FILLET WELDS — The following static strength conclusions are based on the axial tension load (weld transverse shear load) per inch of double fillet weld. Fatigue strength conclusions are based on the axial applied load per square inch of parent metal cross-section.

a. Transverse cruciform joint static strength is linearly proportional to fillet weld size and is in agreement with American Weld Society (Reference 15) published strength values.

b. Concave contoured fillet welds develop higher fatigue strengths than convex contour fillet welds varying from a nominal to a substantial difference.

c. Cruciform joint and tee joint fillet weld fatigue strengths vary essentially inversely with parent metal thickness.

d. The fatigue strength of cruciform joints made with convex contour fillet welds is not adversely affected by weld repairs. The fatigue strengths of transverse tee joints made with convex contour fillet welds are only nominally reduced by normal weld repairs and are not affected by repairs of weld burn-throughs.

e. Flapper peening does not improve fillet weld fatigue strength and can degrade it.

f. Cruciform joints made with full penetration fillet welds exhibit superior strength over such joints made with conventional fillet welds.

5 / STIFFENED PANEL TESTS

5.1 GENERAL

Tests on single bay length stiffened panels were conducted in accordance with TPP00016A (Reference 1) as a progression from coupons to a more complex structure. These tests were basically designed to validate the structural adequacy of typical 3KSES longitudinal panel configurations under axial loading. Test emphasis was on the evaluation of the influence of fabrication parameters such as distortions, straightening operations, repairs and post-weld processing. The panel test specimens were sectioned as replicates from larger flatbar stiffened panel assemblies that were fabricated with various geometric anomalies. All panel assembly welds were subjected to visual and radiographic inspections and were accepted by Quality Assurance as being in conformance with the proposed 3KSES acceptance standards for production welds. In addition, all panel assemblies except for specific panels described below were accepted by Quality Assurance as being in conformance with the proposed 3KSES dimensional tolerance and fairness standards.

5.2 SPECIMEN DESCRIPTIONS

Each stiffened panel test specimen basically consisted of a plate stiffened with two flatbar stringers located on 10-inch centers. All specimens were fabricated from 5456-H116 alluminum alloy and welded using type 5556 aluminum alloy electrodes. A matrix defining the various con-

figurations planned for each of the static tension, static compression and tension fatigue test specimens is presented in Table 5-1. Basic geometrics and dimensions of the various test specimens are illustrated in Figure 5-1; additional details of the test specimens are described in the following paragraphs.

5.2.1 TENSILE STATIC AND FATIGUE TEST SPECIMENS -- These specimens were of the erection joint configuration illustrated in Figure 5-1(a). All specimens were fabricated from 0.250 inch plate and 0.313 x 3.75 inch stiffeners.

5.2.1.1. Tensile Static Test Specimens -- Two configurations of tensile static test specimens were evaluated, i.e., a baseline configuration (TT802022-3) and a configuration with doublers riveted over unwelded stiffener butt joints (TT802022-201). Except for one of the -3 replicates, as discussed in Section 5.7 below, these configurations were free of anomalies and were designed to verify the attainment of basic material allowables in a structure fabricated with practical tolerances. The riveted doubler configuration was intended to evaluate this method as the sole means of butt joining the flat bar stiffeners in situations where welding of these joints may not be practicable.

5.2.1.2 Fatigue Test Specimens -- These stiffened panel specimens were prepared to evaluate the effects of various fabrications parameters such as joint mismatch, straightening operations, repairs and post-weld processing. Two configurations identical to the static tensile specimens (TT802022-3 & -201) were tested to provide baseline data and to evaluate the doubler configuration. Descriptions of other specimens are as follows:

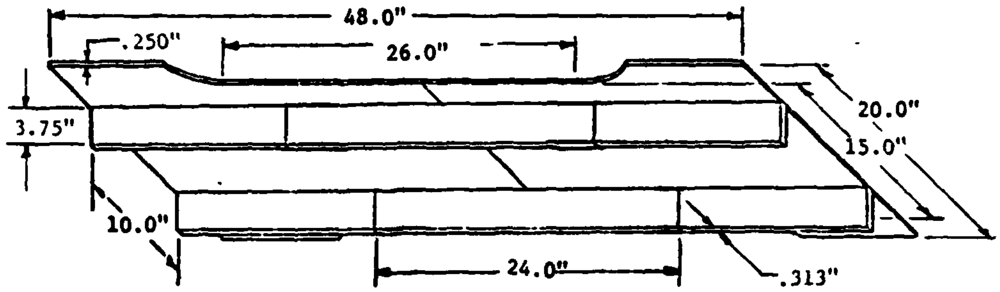
> Specimens No. TT802022-5: These specimens were fabricated similar to the baseline specimens. These specimens were longitudinally bowed by the application of a distributed normal load on the panel stiffener side with the panel ends simply supported. Load was applied incrementally until the

Table 5-1. Flatbar Stiffened Panel Test Specimen Matrix.

Specimen Drawing Number	Primary Investigation Area	Panel Config.		Thickness of Joined Parts					Weld Condition			Panel Condition			Test Type			Quantity	Panel Assembly Drawing Number
		Basic	Erection Joint	.250 Plate .313 Stiff.	.281 Plate .250 Stiff.	.160 Plate .180 Stiff.	.200 Plate .250 Stiff.	.344 Plate .375 Stiff.	As Welded (Note No.)	Weld Repairs (Note No.)	Post Weld Processing (Note No.)	Straight As-Built	Straightened (Note No.)	Mismatched/ Misaligned (Note No.)	Static Tension	Static Compr.	Tension Fatigue		
TT802022-3	Baseline		X	X					X			X			X			2	TT802024-1
-3			X	X					X			X					X	3	-1
TT802023-3	Baseline	X			X				X			X				X		2	-5
TT802023-7	Straightened	X			X				X				(1)			X		2	-7
TT802022-5	Straightened		X	X					X				(1)				X	2	-9
TT802023-101	Eccentricities		X				X		X					(2)		X		2	-15
-201			X					X	X					(2)		X		2	-17
-103			X				X		X					(4)		X		2	-19
-203			X					X	X					(4)		X		2	-21
-105			X				X		X					(5)		X		2	-25
-205			X					X	X					(5)		X		2	-27
-107			X				X		X					(6)		X		2	-29
-207			X					X	X					(6)		X		2	-31
-111			X				X		X					(8)		X		2	-37
TT802023-211	Eccentricities		X					X	X					(8)		X		2	-39
TT802022-11	Post Weld Treatment		X	X					X		(9)			(2)			X	3	-41
TT802022-103	Weld Repairs		X	X						(10)	(10)	X					X	3	-51
-107	Weld Repairs		X	X						(11)	(11)	X					X	3	-53
TT802022-205	Bonded Joint Doublers		X	X						(13)	(13)	X					X	3	-57
TT802022-201	Riveted Joint Doublers		X	X					(14)			X			X			2	-59
TT802023-11			X		X				(14)			X				X		2	-61
TT802022-203			X	X						(15)	(15)	X					X	3	-63
TT802022-201			X	X					(14)			X					X	3	-59
	Total														4	26	23	53	

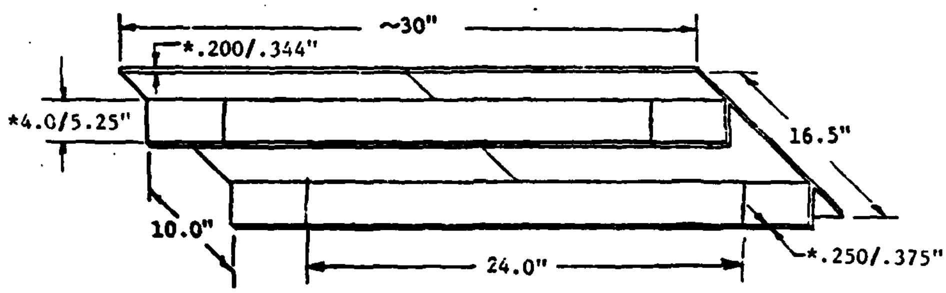
NOTES:

1. Longitudinally bowed panel with tripped stiffeners straightened by jacking and prying.
2. Mismatch at plate and stiffener butt joints.
3. Kinked stiffener butt joints (angular misalignment) with stiffeners bowed laterally 1/4 inch.
4. Stiffeners bowed laterally 1/4 inch.
5. Stiffeners bowed laterally 3/8 inch.
6. Stiffeners bowed laterally 3/8 inch with header installed between stiffeners.
7. Same as Note 2 above, plus rotary brush peening of butt joints.
8. Single weld repairs in plate and stiffener butt joints with brush peening of repaired welds.
9. Same as Note 10, except double and triple weld repairs were made before peening.
10. Doublers adhesively bonded over weld repairs made in plate and stiffener butt joints.
11. Doublers riveted over unwelded stiffener butt joints.
12. Doublers riveted over weld repairs in plate and stiffener butt joints.



Erection Joint Configuration

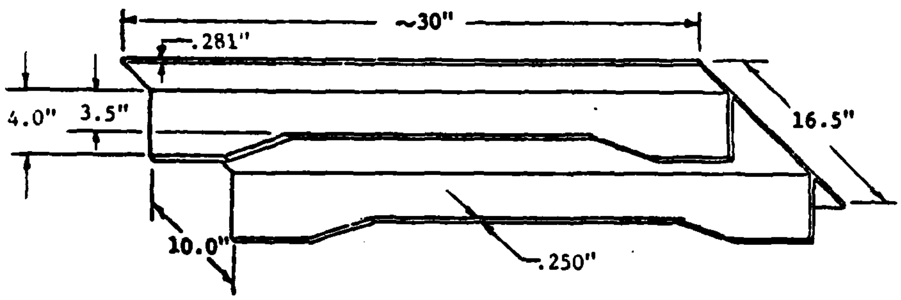
a) **Static and Fatigue Tensile Tests**



*First number for "thin" material configuration; second, for "thick".

Erection Joint Configuration

b) **Compression Buckling Tests**



Basic Panel Configuration

c) **Compression Buckling Tests**

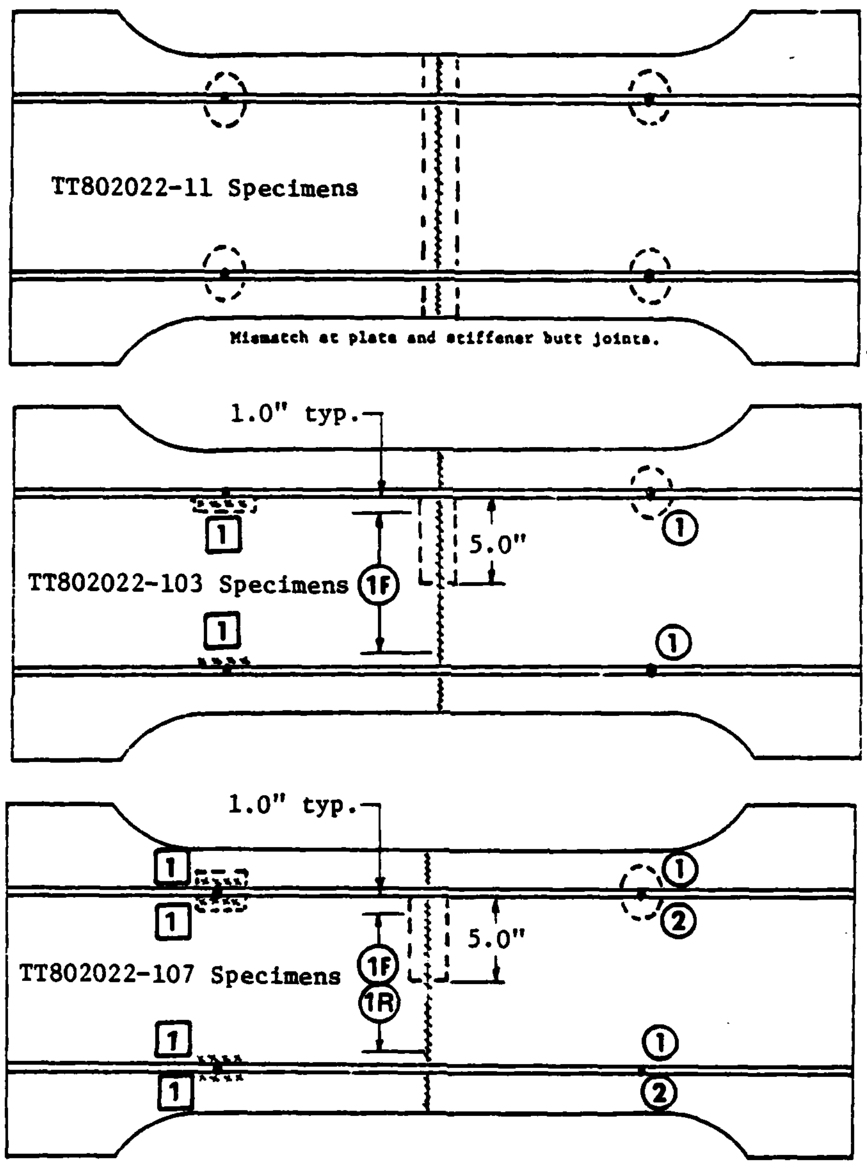
Figure 5-1. Flatbar Stiffened Panel Test Specimen Configurations.

panel was permenently deformed resulting in one-half inch lateral bow in the flat bars. These panels were subsequently straightened before test by jacking and using a slotted pry bar to straighten the stiffeners.

Specimens No. TT802022-11: These specimens were prepared with 1/16 inch nominal mismatch in the plate and stiffener butt joints. Subsequent to welding, the butt joint reinforcements and the stiffener fillets adjacent to the stiffener butt/fillet intersections were smoothed and peened using the rotary flapper process. The peening intensity was .004- .008 Almen A arc height. The location of peened areas is illustrated in Figure 5-2.

Specimens No. TT802022-103: These specimens were prepared to evaluate the effect of single weld repairs and post weld processing of the repaired weld surfaces. Single weld repairs were made in the plate butt joint between the stiffeners, the two stiffener butt joints at one end of the panel and in the inside stiffener fillets adjacent to the stiffener butt joints at the opposite end of the panel. Subsequent to welding, the repaired surfaces on one stiffener and one half the length of the adjacent plate joint were smoothed and rotary flapper peened to 0.004-0.008 Almen A arc height. The locations of the weld repairs and peened areas on the -103 specimens are also illustrated in Figure 5-2.

Specimens No. TT802022-107: These specimens were prepared to evaluate the effect of multiple weld repairs and postweld processing of the repaired weld surfaces. Repairs were in the same locations as on the -103 specimens described above; however, the plate butt weld and the inside and outside fillets at the stiffener butt weld intersection were repaired twice and the stiffener butt welds were repaired three times. The repaired weld surfaces were smoothed and peened as described above for the -103 specimens. The locations of the repairs and peened areas on the -107 specimens are also illustrated in Figure 5-2.



<u>Legend</u>: ☐ = Fillet weld repairs; ◯ = Butt weld repairs

Numbers in symbols indicate single or double repairs.

F = Face side; R = Root side

– – – Brush peened area.

Figure 5-2. Weld Repair and Post-Weld Processing on Stiffened Panel Fatigue Test Specimens.

Specimens No. TT802022-205: These specimens were prepared to evaluate the application of bonded doublers over weld repairs made in the plate and stiffener butt joints. Single weld repairs were made in the plate butt joint between the stiffeners and in the stiffener butt joints on one end of the panel and bonded doublers were installed over these repairs as described in Section 3.6 of this report.

Specimens No. TT802022-203: These specimens were prepared to evaluate the application of riveted doublers over weld repairs made in the plate and stiffener butt joints. The specimens were fabricated similar to the -205 specimens described above except the doublers were installed using rivets instead of adhesive. A 0.160 inch thick doubler was installed on the plate but joint and 0.080 doublers were used on each side of the stiffener joints. These doublers were sized to carry approximately 40 percent of the loads across the joints.

5.2.2 COMPRESSIVE BUCKLING TEST SPECIMENS -- The nominal size of the compression test specimens was 16.5 x 30 inches as illustrated in Figures 5-1(b) and 5-1(c). Detailed descriptions of the various specimens follow.

Specimens No. TT802023-3: These were baseline specimens with haunched stiffeners as illustrated in Figure 5-1(c) and were designed to validate typical 3KSES hull structure panel elements. (After fabrication of these parts, the 3KSES stiffened panel concept was changed from haunched to straight flatbar stiffeners for economic reasons.)

Specimens No. TT802023-7: These specimens were similar to the -3 specimens described above. Prior to testing, the -7 specimens were distorted and straightened (similar to the TT802022-5 tension fatigue panels previously described to evaluate the effect of the straightening operation.

Specimens No. TT802023-11: These specimens incorporated the erection joint and were fabricated with doublers riveted over unwelded stiffener butt joints similar to the TT802022-201 static tensile specimens described in paragraph 5.2.1.1 above. The stiffeners were 4 inch constant height flatbars and all material thicknesses were the same as in the -3 and -7 specimens.

The remaining compression test specimens were fabricated with various eccentricities to evaluate the effect of these fabrication anomalies on panel strength across erection joints. These panels were fabricated with two material thickness combinations for each type of eccentricity in order to investigate the interaction effect of plating stiffness on the flatbar stiffener buckling. The "thin" material combination consisted of 0.200 inch thick plate and 0.250 x 4 inch stiffeners and was intended to produce plate elastic buckling as the most critical buckling mode. The "thick" material combination consisted of 0.344 inch plate and 0.375 x 5-1/4 inch stiffeners and was intended to produce elastic stiffener buckling as the most critical mode. These material thickness combinations also represented typical "light" scantlings and "average" scantlings for the 3KSES longitudinal panel structure. The "thin" and "Thick" specimens are identified by the -1xx and -2xx dash numbers respectively.

Specimens No. TT802023-101 and -201: These specimens were fabricated with offset mismatch in the plate and stiffener butt joints. The amount of mismatch in all "thin" specimen butt joints and in the plate butt joint in the thick specimen was between 1/16 and 1/8 inch; the stiffener butt joints in the "thick" specimens incorporated 1/8 to 1/4 inch mismatch. These tolerances exceed those specified for the 3KSES fabrication in Reference 3 and were used to explore the validity of increasing allowable mismatch.

Specimens No. TT802023-103 and -203: These specimens were fabricated to simulate anerection joint condition in which the stiffeners were bowed and the butt joints on opposite sides of the erection joint were laterally offset in alignment. The amount of offset was extrapolated from actual offsets observed during fabrication of the SES100A bow modification. In order to simulate the most unfavorable condition which could possibly occur, an offset of 1.5 inches was used. By comparison, the allowable offset derived from the requirements of Reference 3 would be 0.50 and 0.57 inch for the "thin" and "thick" specimens respectively. In addition the free edges of the stiffeners on each panel were bowed inward 1/4 inch.

Specimens No. TT802023-105 and -205: These specimens were designed to evaluate the effect of aligned stiffeners with the stiffener edge laterally bowed inward 1/4 inch. This value exceeds the 3/16 allowable bow specified in Reference 3.

Specimens No. TT802023-107 and -207: These specimens were similar to the -105/-205 specimens described above except the amount of stiffener free edge bow was increased to 3/8 inch. These specimens and the -105/-205 specimens were designed to validate the allowable 3/16 offset in the 3KSES structure and to provide a basis for dispositioning production non-conformances.

Specimens No. TT802023-111 and -211: These specimens were similar to the -107/-207 specimens (i.e., 3/8 inch bow in the stiffeners) but with a header installed between the laterally bowed stiffeners at the mid-span point of maximum bow. This configuration was designed to substantiate a possible repair technique.

5.3 SPECIMEN PREPARATIONS

The stiffened panel test specimens were cut from large welded panel assemblies and prepared for testing as described below. From two to five test specimen replicates were obtained from each large panel assembly. Typical assemblies are illustrated in Figure 5-3. Specimen

locations on these assemblies were identified by part number using markings as specified on the stiffened panel specimen drawings number TT802022A and TT802023A. The individual test specimens were rough cut from the panel assembly and trimmed to the specified dimensions as illustrated in Figure 5-4. After trimming, and edge polishing the fatigue specimens, measurements were taken in the locations shown in Figure 5-5. Specimen measured minimum dimensions and calculated section properties are presented in Table 5-2.

5.3.1 TENSILE STATIC AND FATIGUE SPECIMEN PREPARATION -- The full lengths of the reduced section plate edges on all fatigue test specimens were polished to a 32 rms surface finish. Prior to specimen end preparations, specimen out-of-plane distortions was measured, and the location of the neutral axis was scribed on the ends of the panel stiffeners. Specimen distortion measurements are shown in Table 5-3.

Doublers were bonded to the grip ends of the specimens as illustrated in Figure 5-6 to reinforce the grip areas and assure uniform distortion of the applied load from the end fixture into the specimen. The bonding adhesive thickness was controlled and used as a "liquid shim" to attain alignment of the specimens in the test fixtures. The tool used to assemble the doublers onto the specimen was designed to hold the specimen in alignment and to position the doublers to match the mating surfaces of the specimen end grip fixtures so that the adhesive would fill the irregular voids between the specimen and the doublers. The final bonded assembly therefore, fit into the test fixture in such a manner that neither machining or shimming of the specimen was necessary for proper alignment. After the doublers were installed, close tolerance bolt holes were drilled in the specimen ends to match the test fixtures using the TT802029 special drill jib (Reference Appendix A). Provisions for the measurement of strains were installed as described in Section 5.5 below.

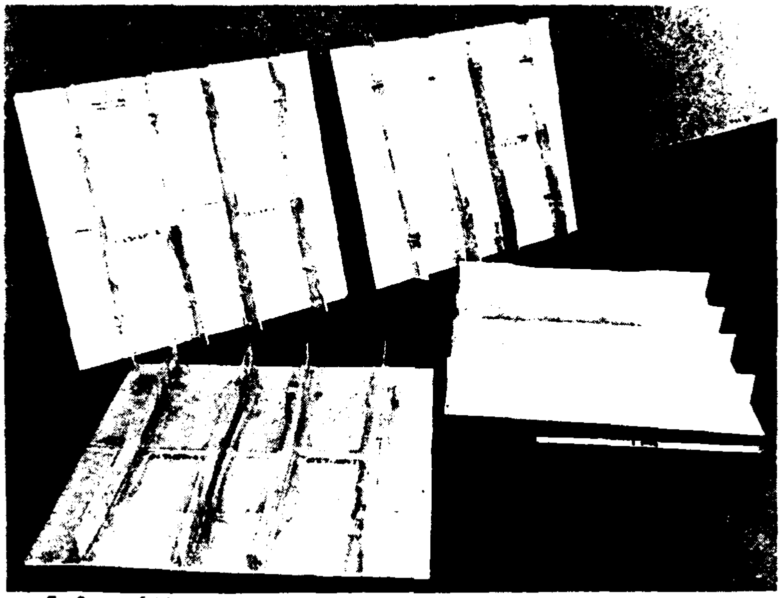
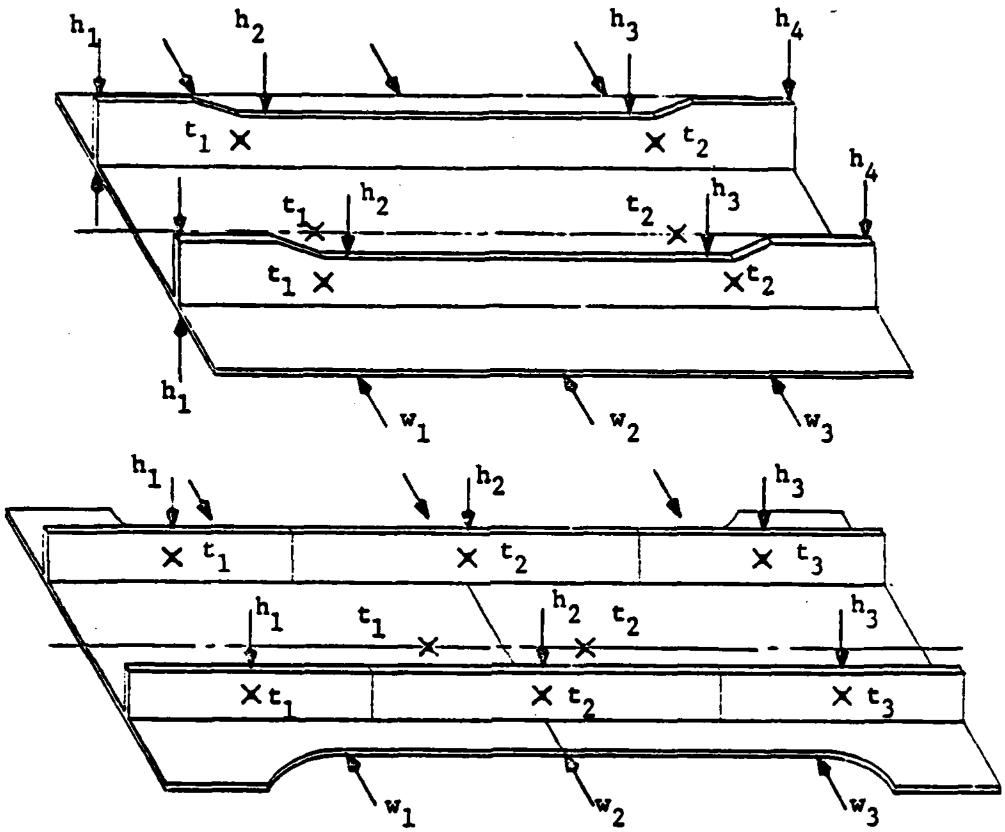


Figure 5-3. (780489-3) Typical Flatbar Stiffened Panel Weld Assemblies for Compression Test Specimens.

Figure 5-4. (790088-1) Final Trimming of Specimen Outline Using Template and Router



Legend: t - Stiffener or plate thickness as indicated on sketches

w - Plate width

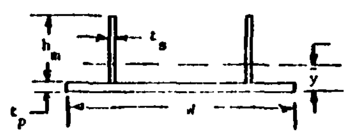
h - Stiffener net height

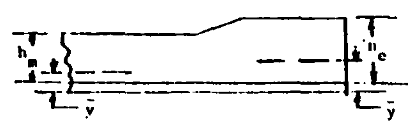
Figure 5-5. Stiffened Panel Specimen Pretest Measurement Locations.

Table 5-2. Stiffened Panel Specimen Minimum Dimensions and Section Properties (Sheet 1 of 2).

SPECIMEN NO.	PLATE		LEFT STIFFENER			RIGHT STIFFENER			AREA (in^2)	MOMENT OF INERTIA (in^4)	$\bar{y}$ (in)
	t_p (in)	W (in)	t_s (in)	h_e (in)	h_m (in)	t_s (in)	h_e (in)	h_m (in)			
A. Static Tension Test Panels(1)											
TT802022-3-S1	.256	14.983	.322		3.750	.322		3.775	6.258	8.871	.906
-3-S2	.260	14.984	.322		3.752	.322		3.744	6.310	8.881	.897
-201-S1	.255	14.989	.320		3.694	.325		3.706	6.205	8.479	.887
TT802022-201-S2	.256	14.982	.325		3.714	.319		3.722	6.230	8.599	.892
B. Tension Fatigue Test Panels(1)											
TT802022-3-F1	.261	14.990	.323		3.705	.321		3.756	6.315	8.740	.890
-3-F2	.260	14.993	.321		3.753	.321		3.705	6.292	8.696	.889
-3-F3	.262	15.005	.319		3.720	.320		3.720	6.305	8.626	.881
-5-F1	.255	15.005	.323		3.670	.325		3.665	6.203	8.327	.879
-5-F2	.255	14.996	.320		3.797	.322		3.745	6.245	8.897	.908
-11-F1	.260	14.980	.321		3.725	.322		3.700	6.279	8.596	.884
-11-F2	.260	14.980	.321		3.690	.320		3.710	6.263	8.497	.879
-11-F3	.262	14.980	.322		3.692	.323		3.724	6.316	8.618	.883
-103-F1	.262	14.982	.319		3.783	.319		3.740	6.325	8.883	.894
-103-F2	.262	14.987	.319		3.805	.322		3.742	6.345	8.987	.900
-103-F3	.261	14.975	.321		3.720	.322		3.725	6.302	8.645	.887
-107-F1	.261	14.994	.323		3.785	.323		3.739	6.344	8.955	.901
-107-F2	.260	14.996	.322		3.750	.323		3.730	6.311	8.975	.894
-107-F3	.260	14.994	.321		3.762	.324		3.720	6.311	8.801	.895
-201-F1	.260	14.988	.322		3.717	.322		3.740	6.298	8.715	.891
-201-F2	.260	14.992	.322		3.730	.317		3.760	6.295	8.775	.893
-201-F3	.258	14.989	.322		3.726	.324		3.736	6.277	8.724	.895
-203-F1	.261	15.000	.321		3.709	.321		3.772	6.317	8.783	.893
-203-F2	.262	14.989	.323		3.760	.323		3.743	6.351	8.903	.897
-203-F3	.261	14.984	.322		3.767	.323		3.770	6.342	8.959	.902
-205-F1	.260	14.991	.322		3.761	.324		3.724	6.316	8.823	.896
-205-F2	.259	14.995	.323		3.754	.323		3.743	6.306	8.849	.899
TT802022-205-F3	.260	14.995	.322		3.735	.323		3.755	6.318	8.836	.897

NOTES: 1) Dimensions are as illustrated in the following sketches.





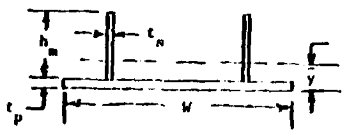
2) Values from left to right are: Area at mid-section, Moment of Inertia at mid-section, and $\bar{y}$ at panel end/$\bar{y}$ at panel mid-section.

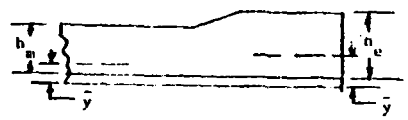
3) Effective neutral axis for haunched stiffeners ($= \bar{y}_e + (\bar{y}_e - \bar{y}_c)\frac{I_c}{(I_e + I_c)}$; where subscripts e and c refer to end and center respectively).

Table 5-2. Stiffened Panel Specimen Minimum Dimensions and Section Properties (Sheet 2 of 2).

SPECIMEN NO.	PLATE t_p (in)	PLATE W (in)	LEFT STIFFENER t_s (in)	LEFT STIFFENER h_e (in)	LEFT STIFFENER h_m (in)	RIGHT STIFFENER t_s (in)	RIGHT STIFFENER h_e (in)	RIGHT STIFFENER h_m (in)	AREA (in^2)	MOMENT OF INERTIA (in^4)	$\bar{y}$ (in)
C. Static Compression Test Specimens(1)											
1T802023-3-1	.279	16.498	.252	4.020	3.529	.252	4.018	3.530	6.630	9.265	.725(3)
								NOTE (2):	6.398	6.593	.797/.674
-3-2	.261	16.496	.253	4.033	3.523	.255	4.017	3.516	6.680	9.368	.723(3)
								NOTE (2):	6.424	6.538	.800/.670
-7-1	.280	16.500	.256	4.011	3.520	.258	4.992	3.500	6.670	9.213	.730(3)
								NOTE (2):	6.444	6.738	.796/.682
-7-2	.279	16.501	.256	3.999	3.550	.256	3.997	3.500	6.646	9.175	.728(3)
								NOTE (2):	6.418	6.680	.795/.680
-11-1	.278	16.508	.260		4.024	.261		3.989	6.673	9.402	.808
-11-2	.275	16.508	.261		4.017	.260		3.996	6.625	9.388	.812
-101-1	.204	16.504	.261		3.919	.253		3.933	5.385	7.984	.876
-101-2	.200	16.503	.253		3.912	.249		3.954	5.283	7.855	.875
-103-1	.199	16.505	.259		4.012	.260		4.028	5.367	8.486	.918
-103-2	.198	16.510	.259		3.988	.260		4.024	5.344	8.394	.915
-105-1	.197	16.498	.258		4.000	.259		3.998	5.314	8.316	.913
-105-2	.199	16.500	.260		4.012	.259		4.005	5.360	8.418	.914
-107-1	.201	16.494	.261		4.068	.257		4.018	5.410	8.643	.922
-107-2	.202	16.501	.259		4.013	.262		3.994	5.423	8.485	.912
-111-1	.199	16.508	.259		3.963	.258		3.973	5.333	8.173	.900
-111-2	.198	16.503	.259		3.955	.262		3.982	5.339	8.234	.907
-201-1	.343	16.515	.365		5.273	.361		5.271	9.492	26.924	1.304
-201-2	.345	16.507	.365		5.282	.366		5.279	9.549	27.194	1.308
-203-1	.345	16.503	.364		5.274	.363		5.292	9.529	27.124	1.305
-203-2	.344	16.472	.364		5.271	.364		5.282	9.508	27.055	1.308
-205-1	.346	16.508	.367		5.280	.366		5.280	9.577	27.277	1.308
-205-2	.348	16.514	.367		5.309	.363		5.275	9.610	27.445	1.308
-207-1	.348	16.505	.367		5.310	.365		5.300	9.627	27.675	1.314
-207-2	.345	16.514	.364		5.302	.367		5.280	9.577	27.410	1.312
-211-1	.346	16.505	.363		5.268	.362		5.275	9.538	27.003	1.300
1T802023-211-2	.344	16.518	.362		5.250	.363		5.255	9.542	26.631	1.294

NOTES: 1) Dimensions are as illustrated in the following sketches.





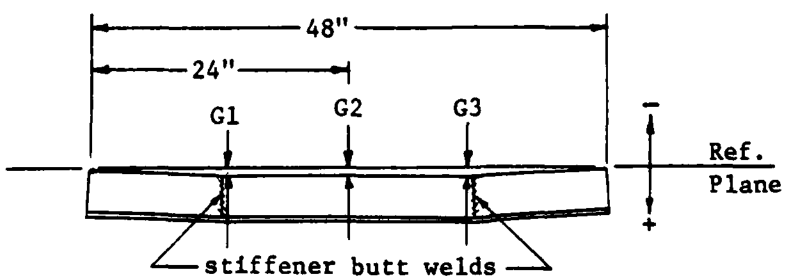
2) Values from left to right are: Area at mid section, Moment of Inertia at mid-section, and $\bar{y}$ at panel end/$\bar{y}$ at panel mid-section.

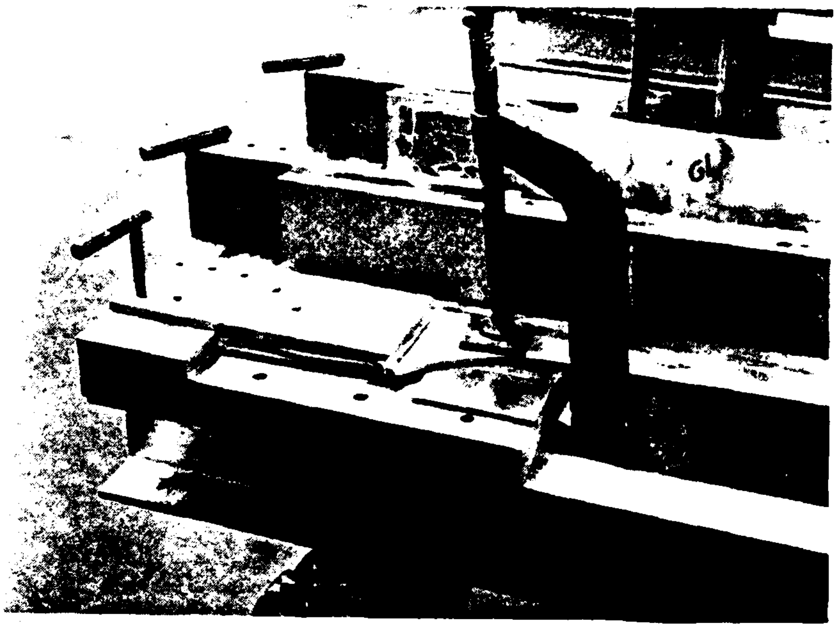
3) Effective neutral axis for haunched stiffeners ($= \bar{y}_e + (\bar{y}_e - \bar{y}_c) \frac{I_c}{(I_e + I_c)}$; where subscripts e and c refer to end and center respectively).

Table 5-3. Stiffened Panel Tensile Static and Fatigue Test Specimen Distortions.

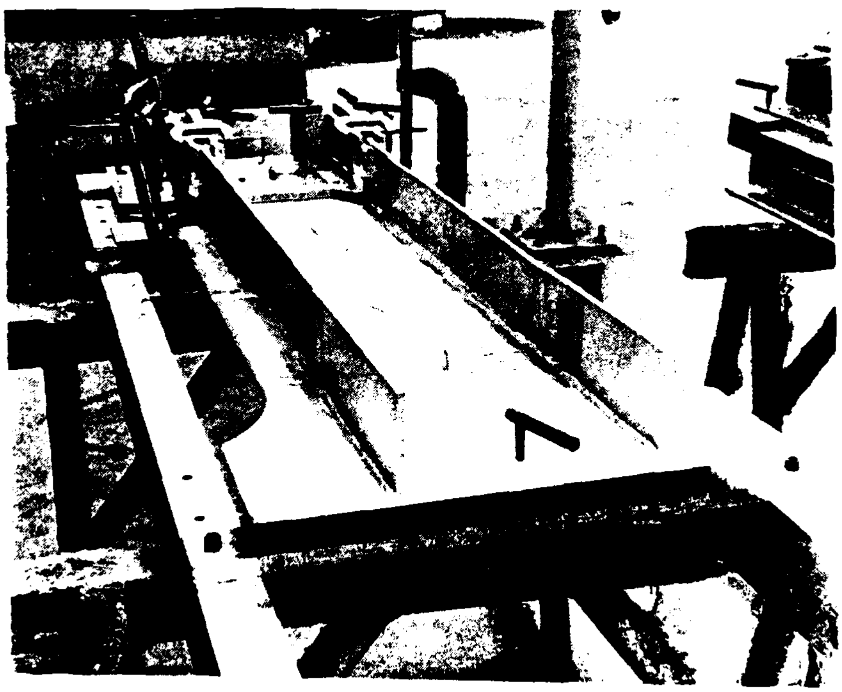
Specimen No. TT802022-	Left Stiffener Distortion*			Right Stiffener Distortion*		
	G1	G2	G3	G1	G2	G3
-3-S1	.225	.190	.230	.450	.390	.340
-3-S2	NOT RECORDED					
-201-S1						
-301-S2						
-3-F1	.260	.180	.150	.380	.360	.360
-3-F2	.180	.170	.190	.520	.430	.325
-3-F3	.210	.200	.260	.170	.140	.160
-5-F1	.000	-.050	.100	.050	.030	.080
-5-F2	-.020	-.080	.100	.090	.000	.070
-11-F1	.160	.160	.160	.170	.115	.115
-11-F2	.150	.140	.140	.240	.230	.290
-11-F3	.270	.230	.250	.210	.230	.205
-103-F1	.180	.080	.150	.100	.080	-.020
-103-F2	.125	.020	.050	.120	.065	.100
-103-F3	.130	.015	.060	.175	.060	.060
-201-F1	.025	.015	.015	-.050	-.040	.000
-201-F2	-.020	-.010	.020	-.040	-.010	.010
-201-F3	-.070	-.010	-.040	-.030	-.030	-.020
-203-F1	.140	.170	.160	.115	.170	.150
-203-F2	.200	.135	.165	.150	.110	.165
-203-F3	.240	.140	.250	.120	.115	.180
-205-F1	.130	.050	.010	.180	.145	.175
-205-F2	.140	.180	.180	.130	.130	.140
-205-F3	.050	.030	.070	.080	-.020	.100
-107-F1	.170	.080	.170	.240	.190	.230
-107-F2	.200	.080	.080	.250	.175	.130
-107-F3	.300	.180	.170	.150	.070	.100

*Distortion measurements in inches at locations illustrated below.





(a) (790461-3) Detail of Doubler Bonding in Progress.



(b) (790461-6) Overall View with Bonding Completed at Far End of Specimen.

Figure 5-6. End Doubler Bonding - Stiffened Panel Tensile Static and Fatigue Test Specimens.

5.3.2 COMPRESSION BUCKLING SPECIMEN PREPARATION -- As indicated in Figure 5-7, both ends of the compression test specimens were plotted into 17 inch long sections of aluminum channel extrusions using steel filled epoxy potting compound. Channel dimensions were 6 x 2 inches for the specimens with 4 inch height stiffeners and 7 x 2.3 inches for specimens with 5 1/4 inch height stiffeners. The plotting operation was performed on a flat machined surface using steel squares to insure perpendicularity; this operation is illustrated in Figure 5-8. Provisions for the measurement of strains and deflections were installed as described in Section 5.5 below.

5.4 TEST SETUPS AND FIXTURES

5.4.1 STATIC TENSION TESTS -- The statis tension tests were setup in a Tinius-Olsen Universal Testing Machine of 300,000 pound capacity. Specially configured specimen end grip fixtures were centered and clamped in the test machine wedge grips at the upper and lower heads. The test panel specimen was installed in these grips. Details of these end grip fixtures, which were modifications of stiffened panel grips from the H-5 Advanced Development Program, are provided in Appendix A. A specially designed and fabricated 10 inch gage length extensometer was installed on the specimen centered over the plate erection joint butt weld. Photographs of the overall test setup and the extensometer installation are presented in Figure 5-9.

5.4.2 TENSILE FATIGUE TESTS -- The basic setup for these tests consisted of a structural steel load frame with an MTS No. 204-81B.05 hydraulic actuator and a 1110,000 pound capacity strain gaged load cell mounted at opposite ends. The same basic end grip fixtures employed for the stiffened panel static tensile tests were also used for the fatigue tests. These fixtures were connected through spherical bearing rod ends to the actuator shaft and the load cell. With the test panel mounted between the grips, this arrangement assured that the required load was transmitted through the test specimen. A sketch of the basic setup is shown in Figure 5-10 and photographs are presented in Figure 5-11.

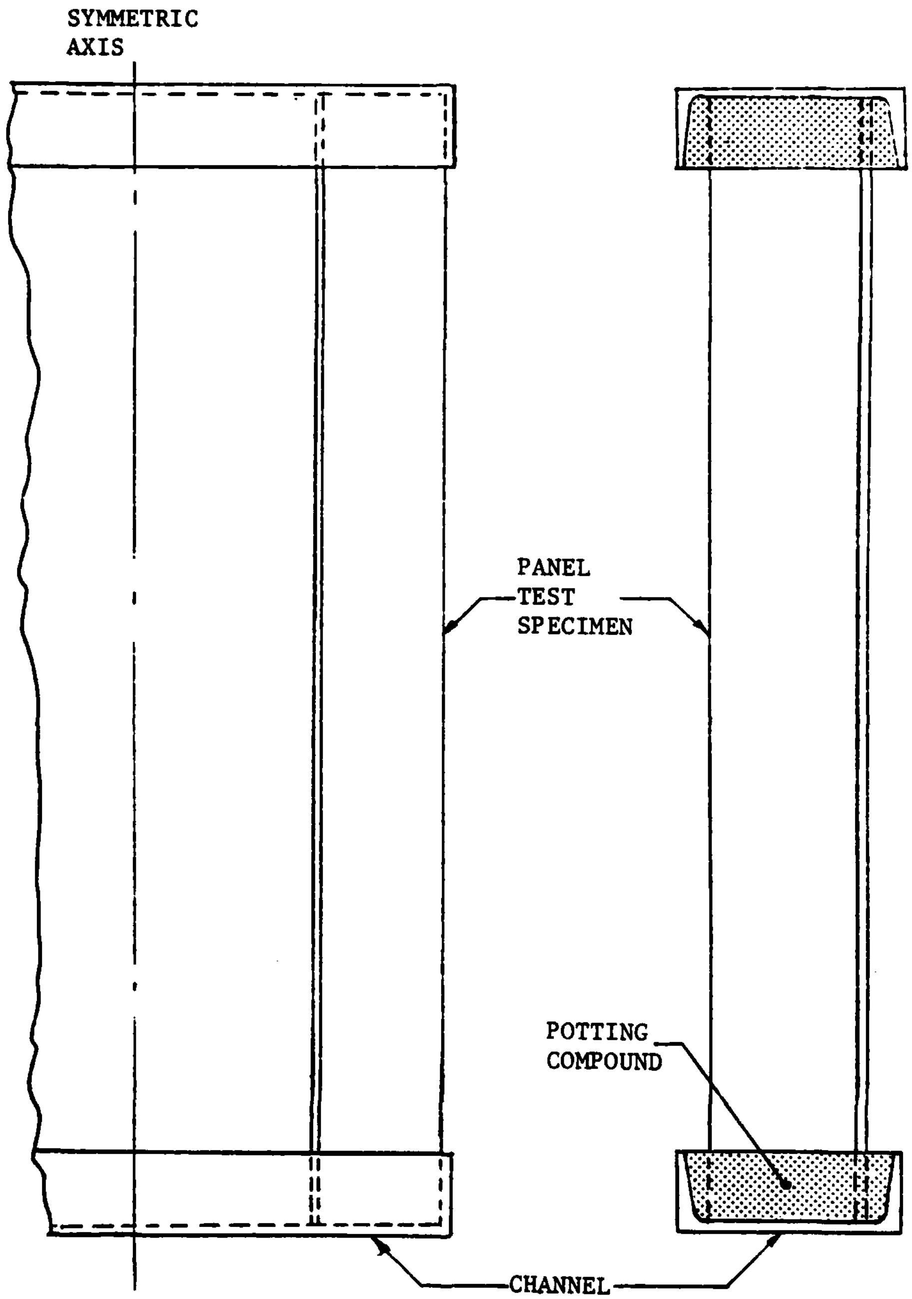


Figure 5-7. End Preparation for Compression Test Specimens.

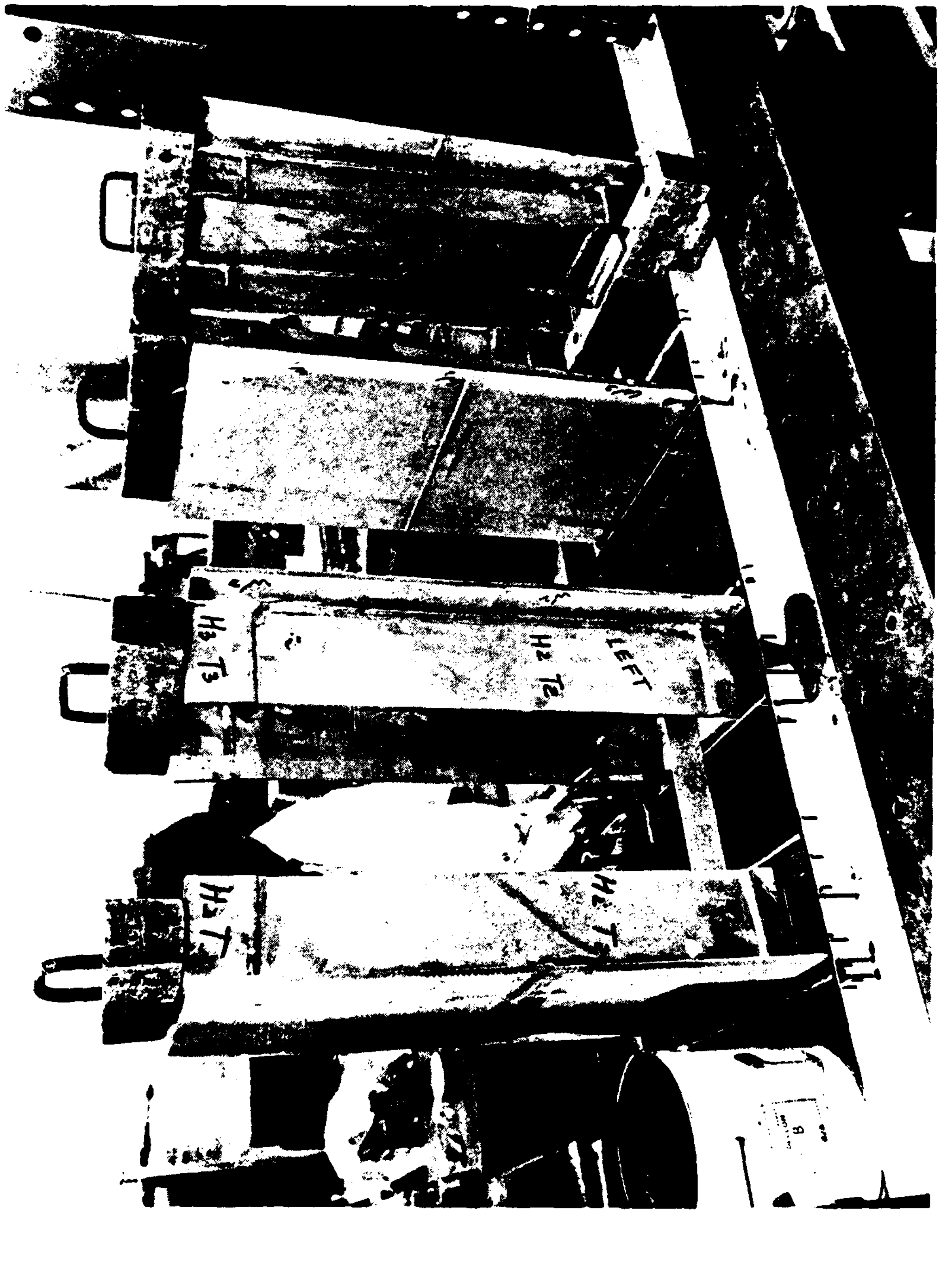
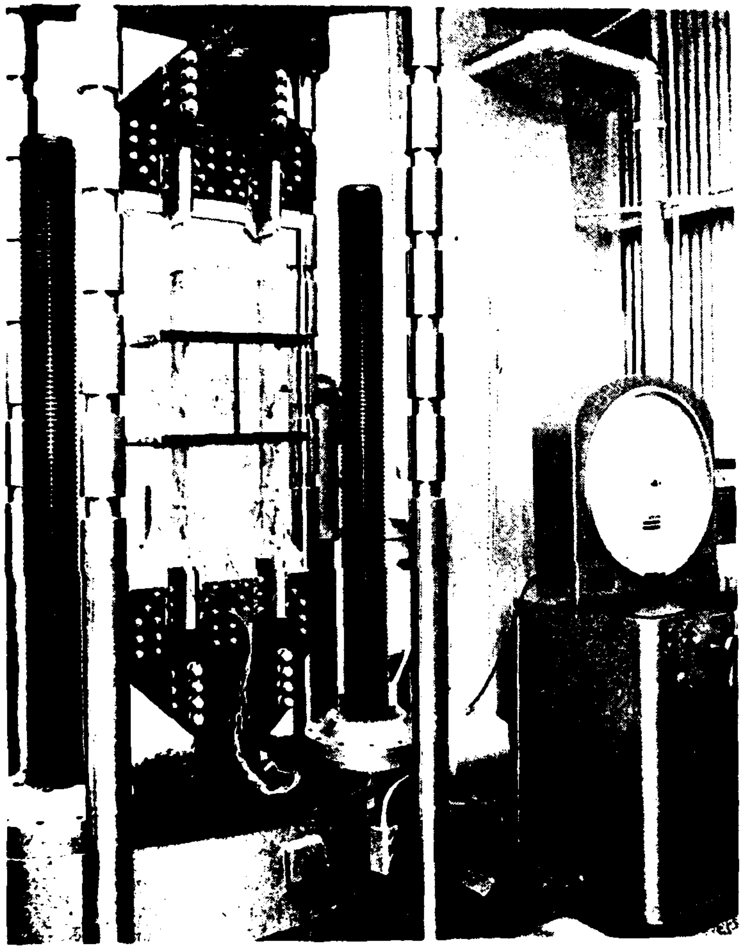
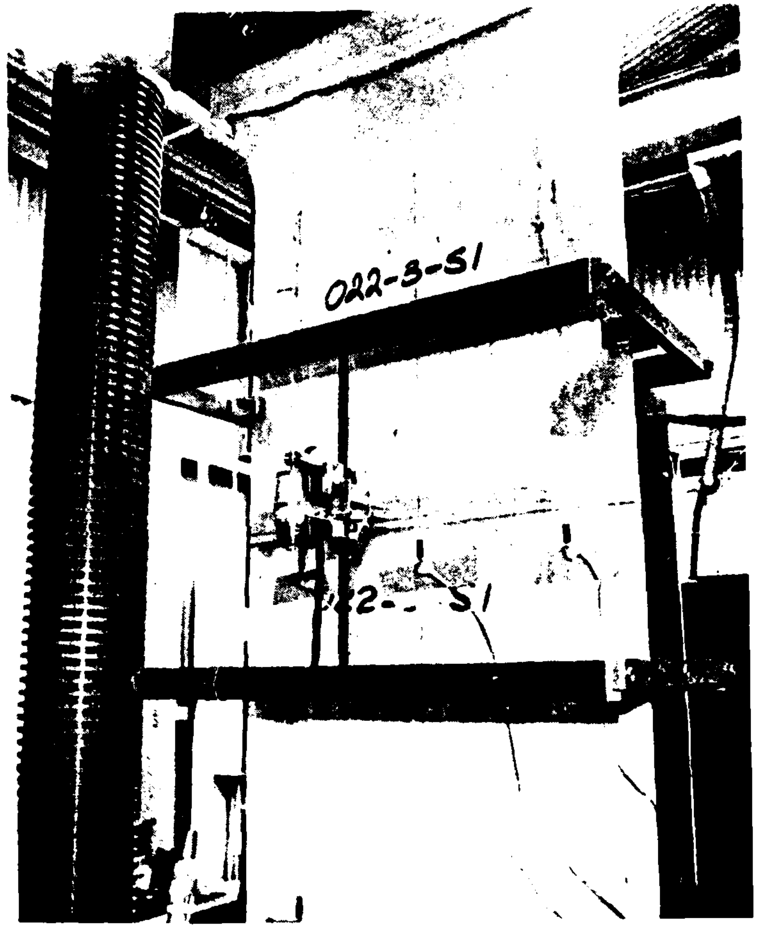


Figure 5-8. (780398-1) End Plotting of Stiffened Panel Compression Test Specimens.



(a) (790046-1) Overall View.



(b) (790046-3) 10-Inch Gage Length Extensometer Installation Detail.

Figure 5-9. Stiffened Panel Static Tension Test Setup in Tinius-Olsen Test Machine.

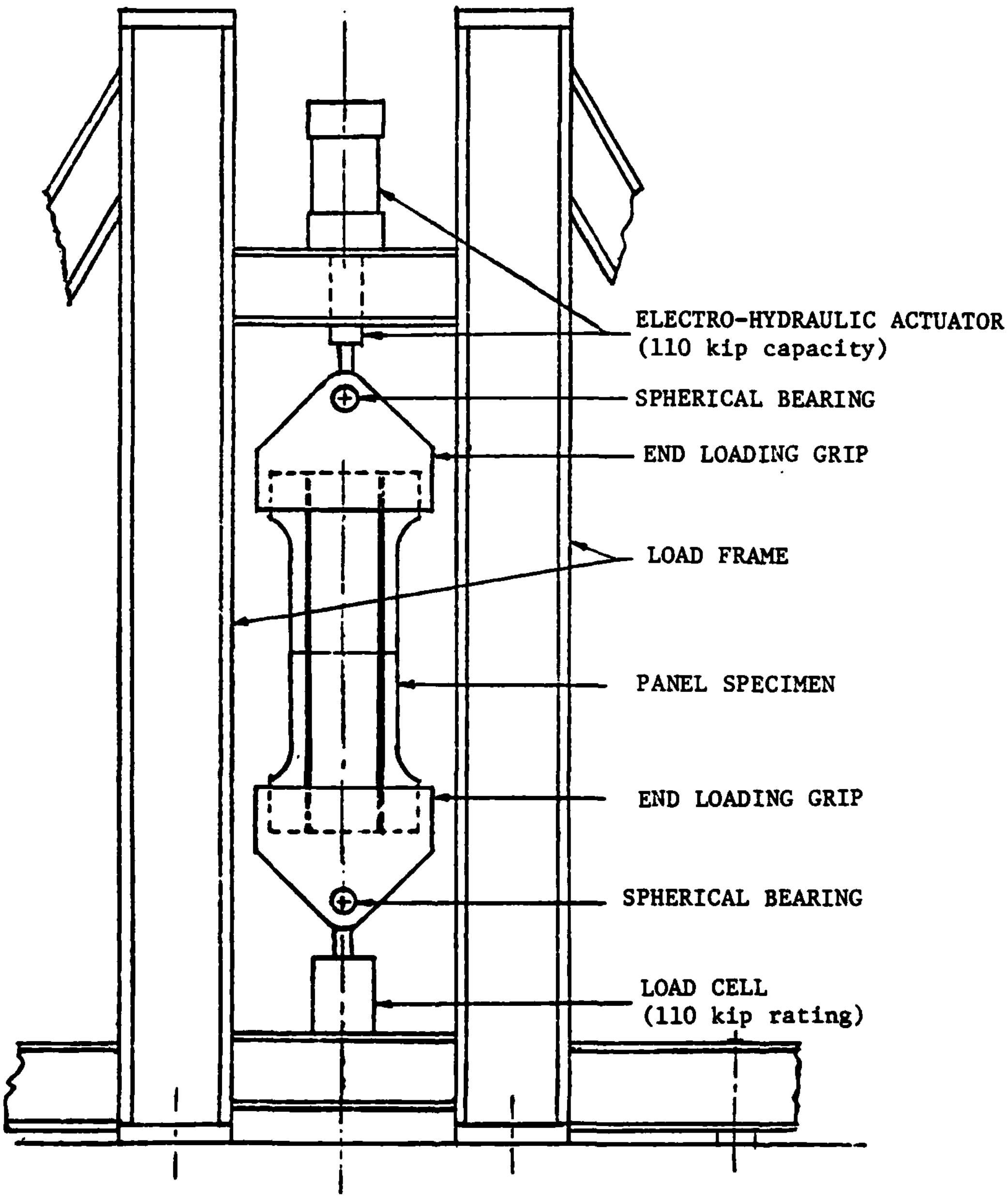
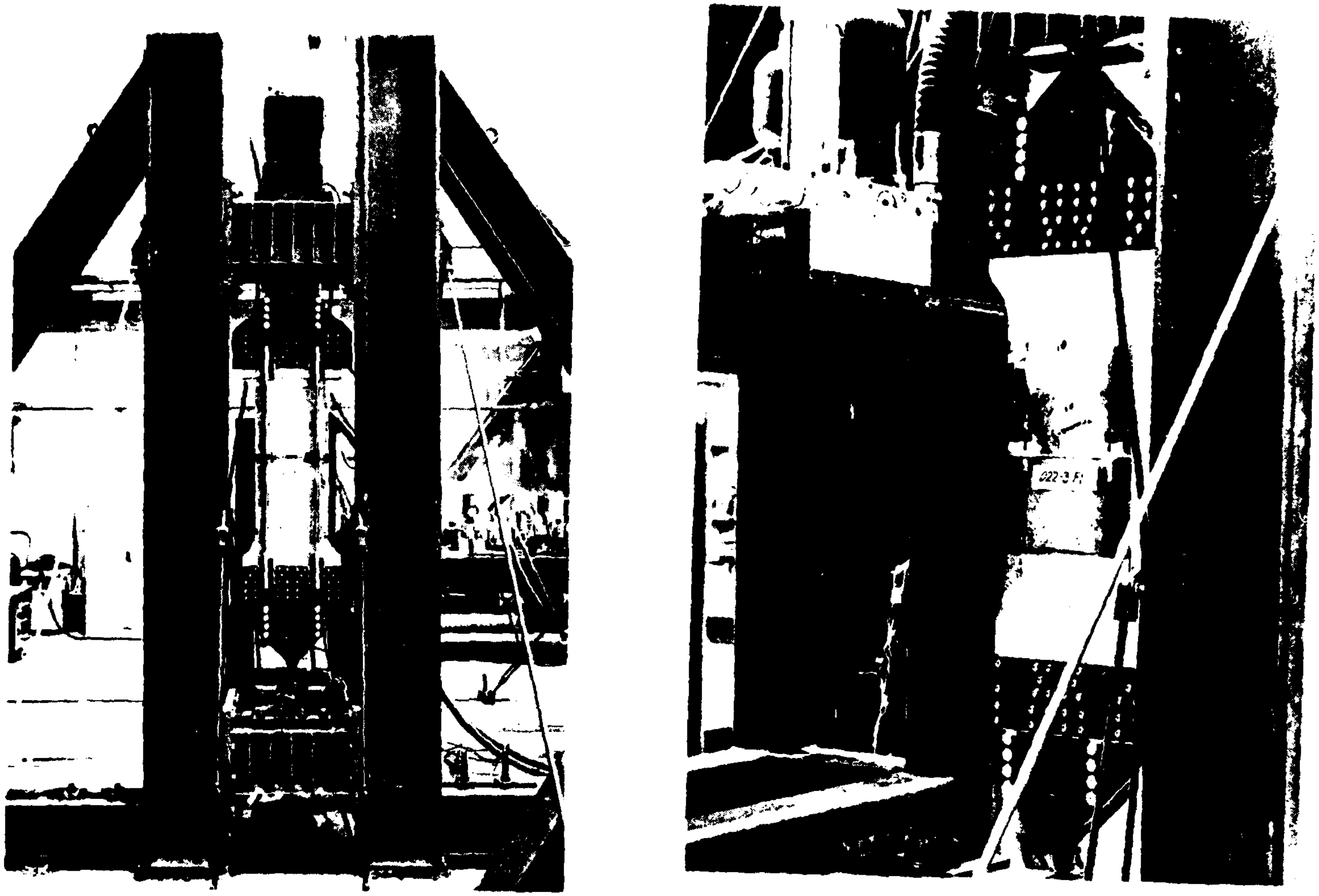


Figure 5-10. Stiffened Panel Fatigue Test Setup Components.



(a) (790117-1) Overall Front View

(b) (790117-3) Rear View

Figure 5-11. Stiffened Panel Tensile Fatigue Test Setup.

The load control system employed for testing eleven of the stiffened panel fatigue tests consisted of a Varian 620/i computer with ASR33 Teletype input/output and master control panel coupled to an MTS 406.11A01 servo controller and control panel. The command signal was generated by the computer in the form of a haversine wave shape between the specified load level. Control of the hydraulic actuator was affected through a 170 gallon per minute capacity servovalve connected to the control system. A feedback signal to the control system was provided from the load cell. Safety interlock and shutdown features were also incorporated in the overall control system setup. A view of the control room showing the computer system and associated control and recording equipment is presented in Figure 5-12(a).

Approximately midway through the stiffened panel fatigue test program, a failure occurred in the Varian computer. In order to expedite the completion of testing, the Varian computer and the Teletype were replaced with an MTS Model 410 Digital Function Generator and an Anadex Model CF-500 Electronic Counter for the balance of the stiffened panel fatigue tests. A photograph of the load control equipment after this change is shown in Figure 5-12(b).

Failures in the specimen and grip fixtures were also experienced during the course of fatigue testing. The first failure occurred, after 820,000 accumulated fixture cycles, through the 3-inch diameter loading pin hole as shown in Figure 5-13(a). Two spare fixture base plates remaining from the H-5 program were available and, after magnaflux inspection, one of these was modified to the current configuration and substituted for the failed part. This replacement base plate failed in a manner almost identical to the first after 1,312,000 additional fixtures cycles. Both of the failed base plates were examined metallurgically for defects or other problems. When no specific cause for these failures could be established other than fatigue initiation at low stress levels, a design modification was implemented after reworking the remaining H-5 base plate to the current configuration. The bore of all the lug loading pin

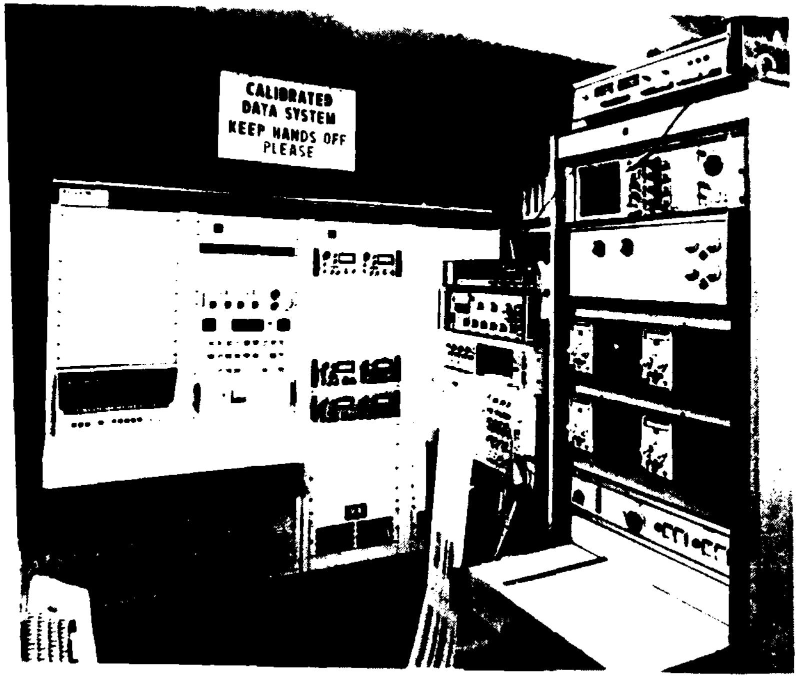
holes and adjacent flat areas were surface ground, doublers, as illustrated in Figure 5-13(b), were installed on the upper and lower base plates. This modification proved successful throughout the remainder of the fatigue tests.

5.4.3 STATIC COMPRESSION TESTS -- These tests were set up in the Tinius-Olsen 300,000 pound capacity Universal Testing Machine using end fixtures designed for these test specimens. These fixtures provided pin-ended support about the panel minor axis and line support along the panel major axis at each end. Lateral adjustment for precise alignment of the pin axis with the panel neutral axis was provided by adjusting screws as illustrated in Figure 5-14. Due to slight deviations from trueness at the test specimen ends, occassional shimming between the upper fixture and the machine head was required to achieve uniform line contact prior to loading.

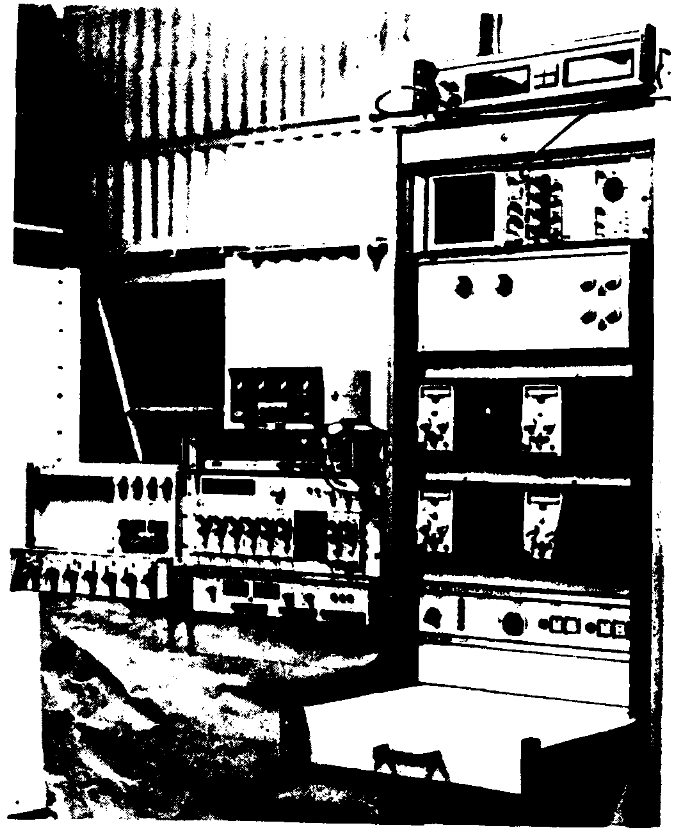
The test panel was installed between the end fixtures, aligned on the scribed loading axis, and clamped to the fixtures. An "erector set" framework was positioned around the test area to support deflection transducers. The deflection transducer cables were then attached to the specimen measurement points with standard wire leaders. The total setup, including a detail view of typical deflection transducer connections, is shown in Figure 5-15.

5.5 INSTRUMENTATION AND DATA ACQUISITION EQUIPMENT.

Each of the various specimens was instrumented with strain gages at the locations defined in Figure 5-16 and 5-17. The locations of displacement measurements for each of the compression panels are defined in Figure 5-18. The actual strain and displacement measurement locations shown in these figures represent minor deviations from the Reference 1 Test Plan necessitated by specimen geometry constraints.

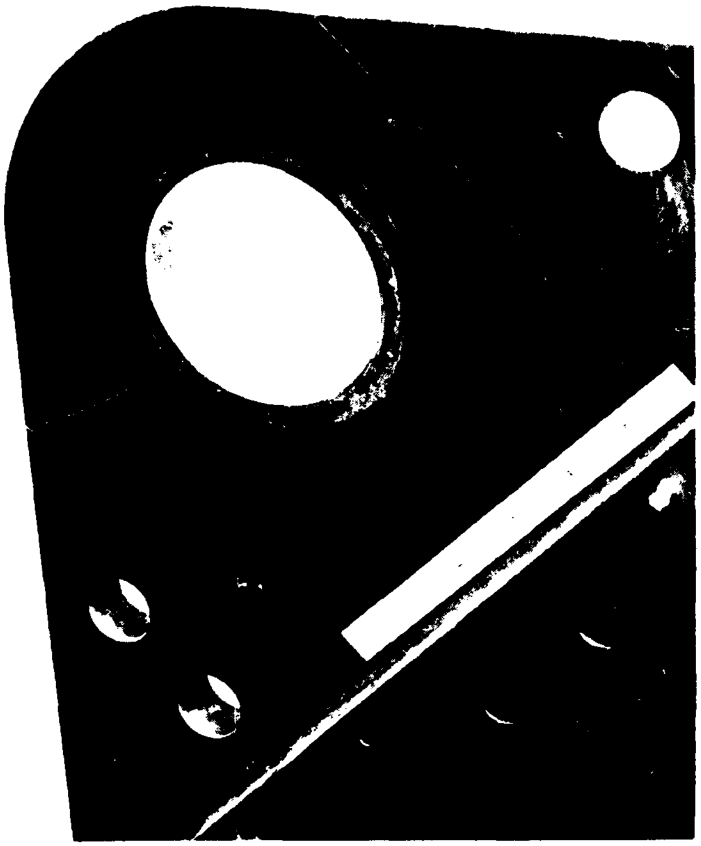


(a) (790117-5) Computer Control System Equipment

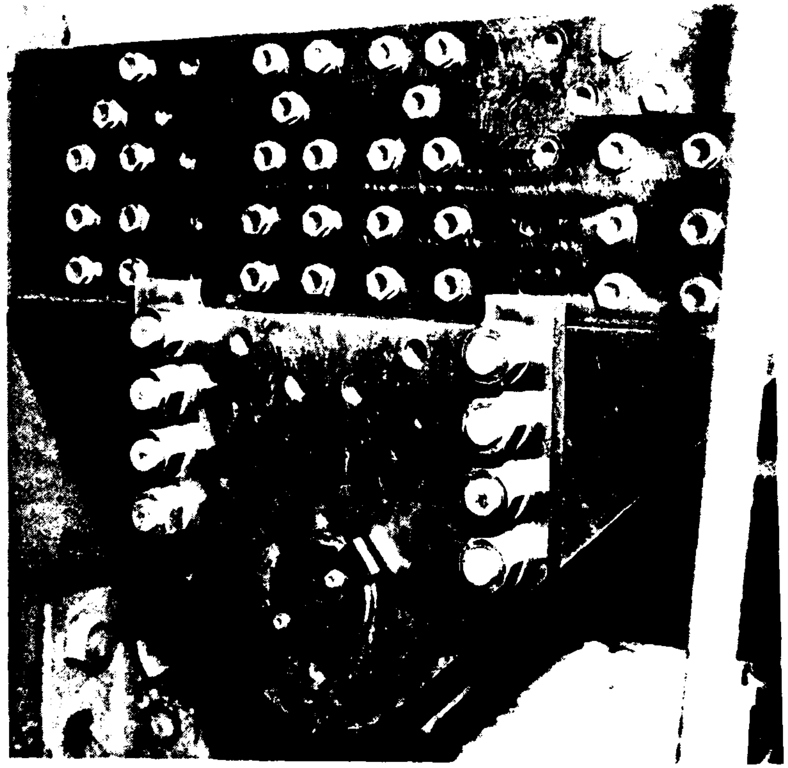


(b) (790958-1) Function Generator Control System Equipment

Figure 5-12. Stiffened Panel Fatigue Cycling Test System Control and Recording Equipment.



(a) (790160-1) Failure of Upper Grip Base Plate (P/N TT802025-101).



(b) (790484-1) Doubler Installation Reinforcement of Grip Base Plate.

Figure 5-13. Grip Failure and Reinforcement Modification.

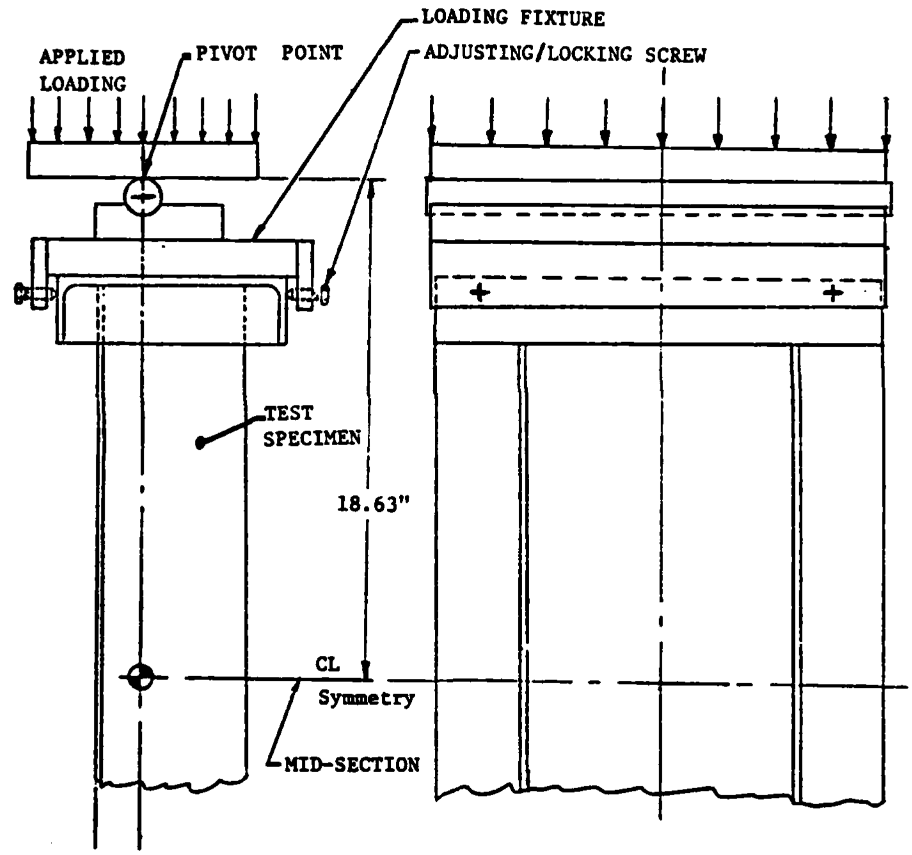
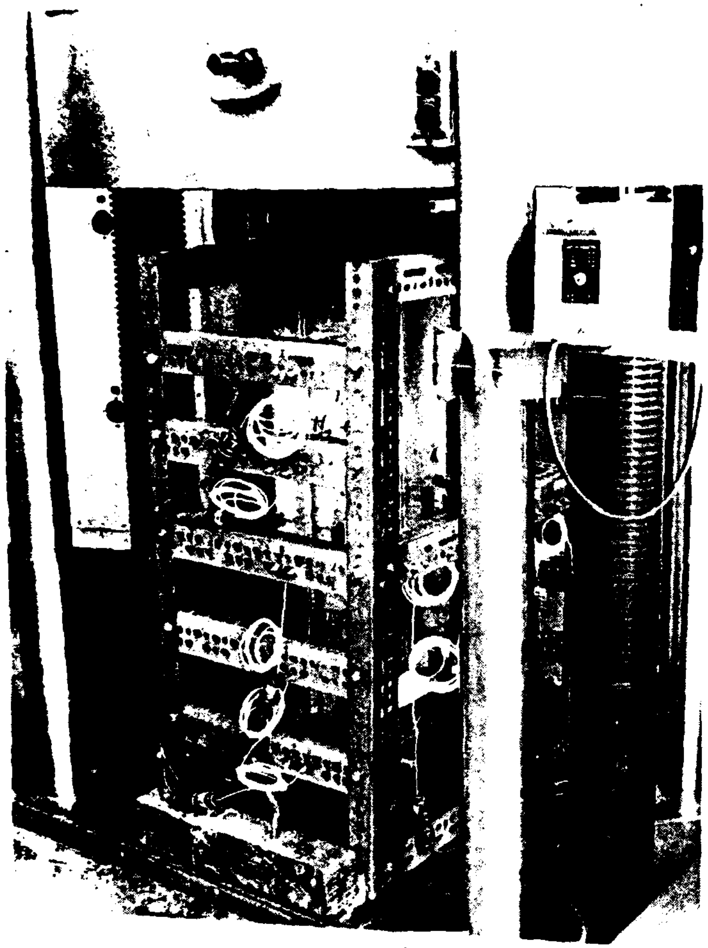


Figure 5-14. Stiffened Panel Compression End Loading Fixture Setup.



(a) (780709-3) Overall View.

(b) (780709-2) Deflection Transducer Attachment Details.

Figure 5-15. Stiffened Panel Static Compression Test Setup in Tinius-Olsen Test Machine.

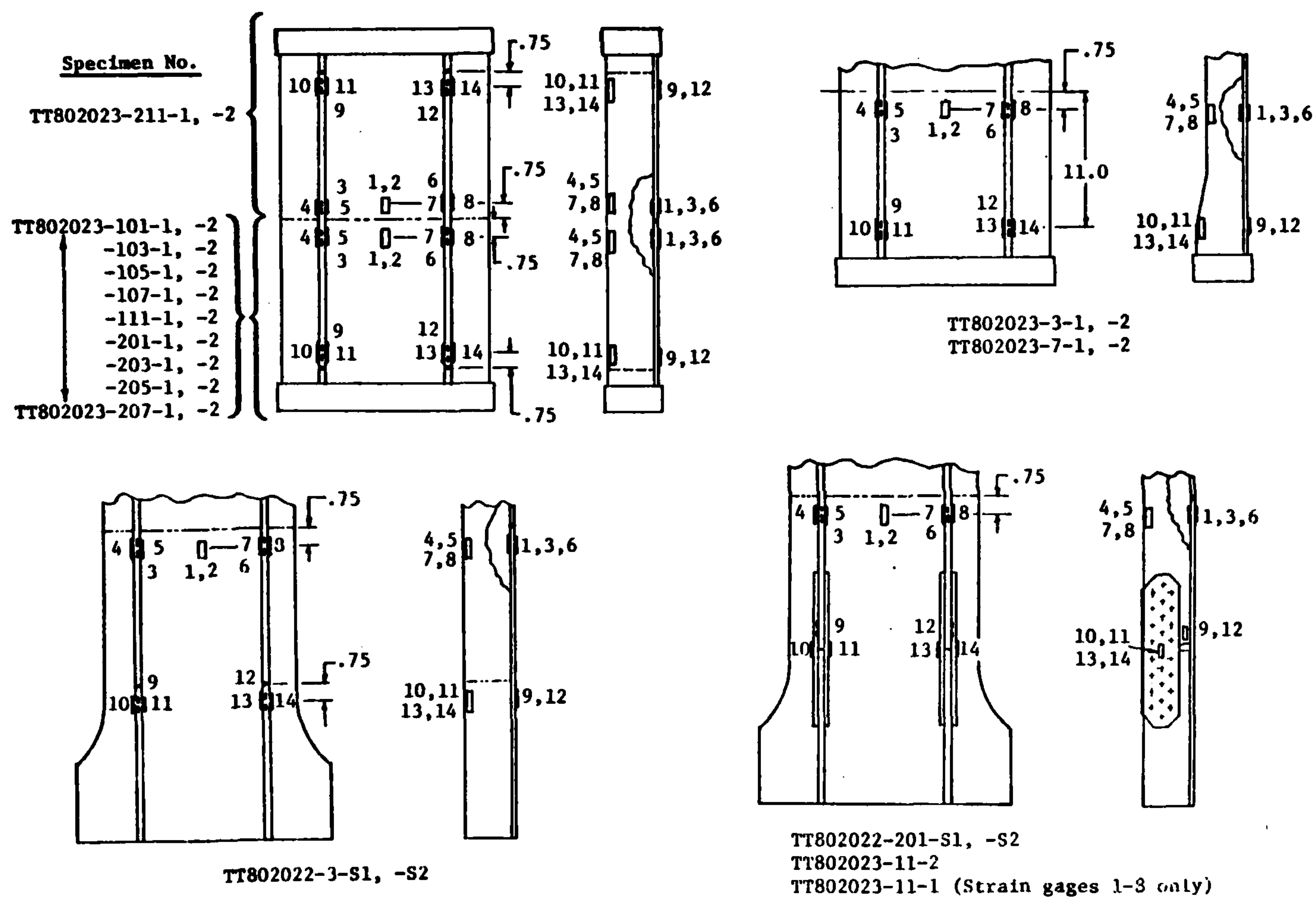


Figure 5-16. Strain Gage Identification, Locations and Orientations on Stiffened Panel Static Tension and Compression Test Specimens.

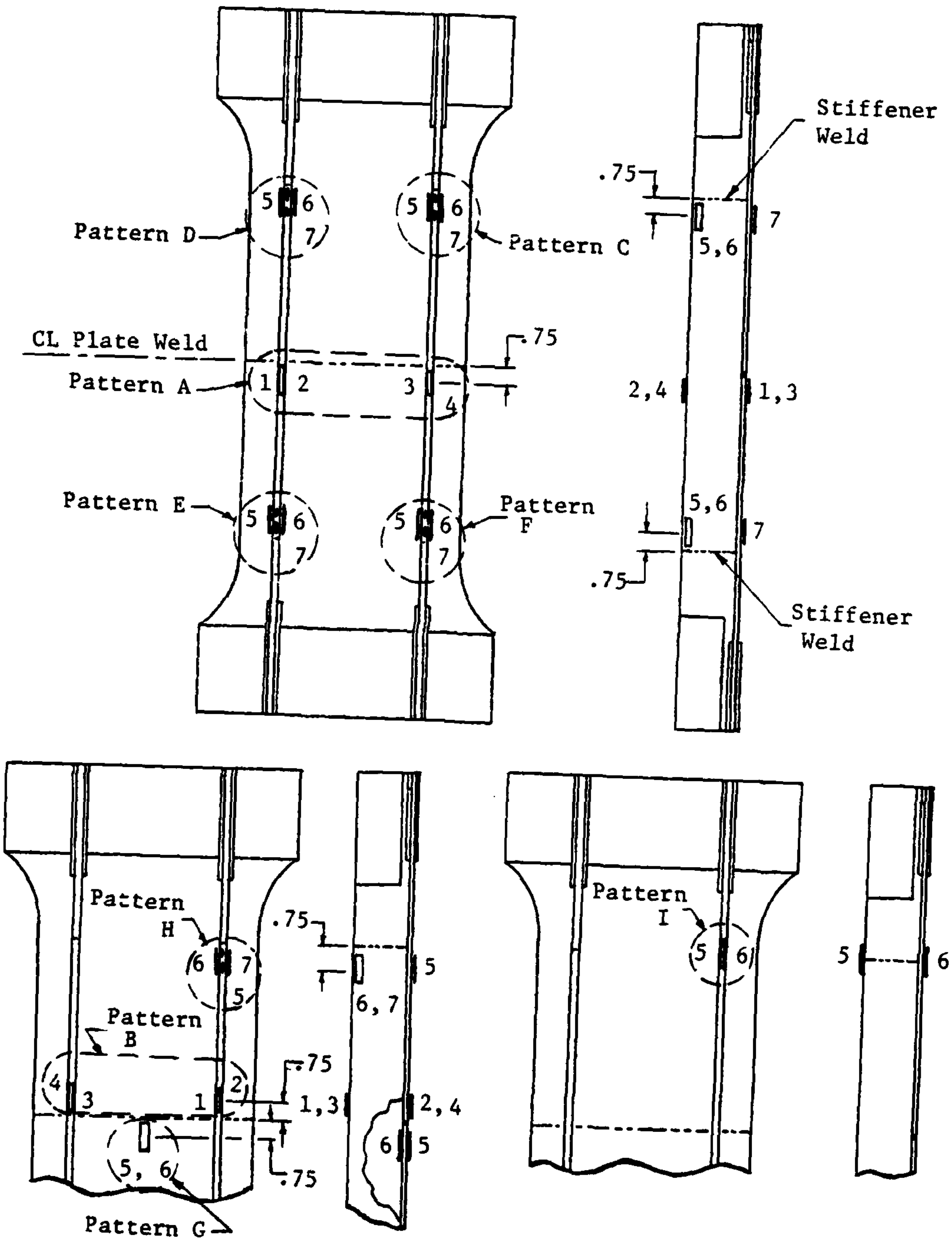
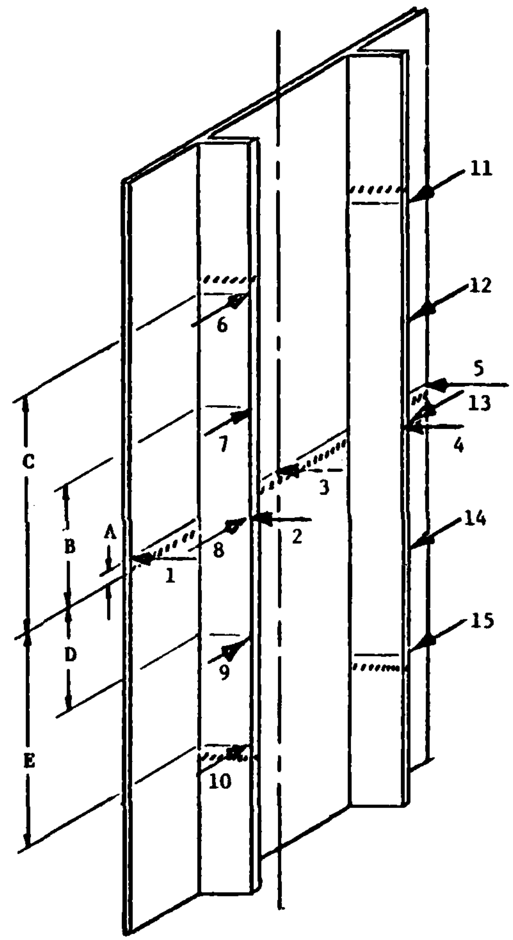


Figure 5-17. Strain Gage Identifications, Locations and Orientations on Stiffened Panel Tensile Fatigue Test Specimens. (Sheet 1 of 2).

STIFFENED PANEL SPECIMEN NO.	APPLICABLE STRAIN GAGE PATTERNS from Sheet 1
TT802022-3-F1	B, H
TT802022-3-F2	A, C
TT802022-3-F3	A, E
TT802022-5-F1	A
TT802022-5-F2	A
TT802022-11-F1	A, H
TT802022-11-F2	A, F
TT802022-11-F3	A, D
TT802022-103-F1	A, D
TT802022-103-F2	A, D
TT802022-103-F3	A, C
TT802022-107-F1	A, C
TT802022-107-F2	A, C
TT802022-107-F3	A, D
TT802022-201-F1	A, G
TT802022-201-F2	A
TT802022-201-F3	A
TT802022-203-F1	A
TT802022-203-F2	A, D
TT802022-203-F3	A, D
TT802022-205-F1	A, I
TT802022-205-F2	A, E
TT802022-205-F3	A

Figure 5-17. Strain Gage Identifications, Locations and Orientations on Stiffened Panel Tensile Fatigue Test Specimens (Sheet 2 of 2).

Specimen No. TT802023 -	Dimensions (inches)				
	A	B	C	D	E
-3-1	.5	6.0	11.5	6.0	11.5
-3-2	.5	6.0	11.5	6.0	11.5
-7-1	.5	6.0	11.5	6.0	11.5
-7-2	.5	6.0	11.5	6.0	11.5
-11-1	.5	3.0	11.5	3.0	11.5
-11-2	.5	3.0	11.5	3.0	11.5
-101-1	.5	6.0	11.5	6.0	11.5
-101-2	.5	6.0	11.5	6.0	11.5
-103-1	.5	6.0	11.25	6.0	11.25
-103-2	.5	6.0	11.25	6.0	11.25
-105-1	.5	6.0	11.5	6.0	11.5
-105-2	.5	6.0	11.5	6.0	11.5
-107-1	.5	6.0	11.5	6.0	11.5
-107-2	.5	6.0	11.5	6.0	11.5
-111-1	.5	6.0	11.5	6.0	11.5
-111-2	.5	6.0	11.25	6.0	11.25
-201-1	.5	6.0	11.25	6.0	11.25
-201-2	.5	6.0	11.25	6.0	11.25
-203-1	.5	6.0	11.0	6.0	11.0
-203-2	.5	6.0	11.0	6.0	11.0
-205-1	.5	6.0	11.25	6.0	11.25
-205-2	.5	6.0	11.25	6.0	11.25
-207-1	.25	5.75	11.5	6.25	11.5
-207-2	.5	6.0	11.5	6.0	11.5
-211-1	.5	6.0	11.5	6.0	11.5
-211-2	.5	6.0	11.5	6.0	11.5



Note: Direction of arrow indicates positive deflection.

Figure 5-18. Deflection Measurement Designations and Locations for Stiffened Panel Compression Test Specimens.

The following transducers were employed:

ITEM	MANUFACTURER	DESCRIPTION
Strain Gage	MicroMeasurements, Incorporated	EA-13-250BG-120 Static Range: ± 5000 micro in/in Fatigue Endurance 10 cycles at ± 1450 micro in/in
Displacement Transducer	Research Inc.	Model 4046-2 Range: 0-2 in. Accuracy: ± 1% of max. range
Extensometer	Tinius-Olsen	Model S-400-2AB in conjunction with specially fabricated 10-inch gage length extensometer frame.

Standard mounting tabs, with pressure sensitive adhesive backing, were attached to the specimens and connected to the displacement transducers with wire leaders. The strain gages were bonded using standard test laboratory installation techniques.

The data acquisition system used for each type of test is described in the following paragraphs. All measuring equipment displayed evidence of current calibration traceable to standards maintained by the National Bureau of Standards.

5.5.1 DATA ACQUISITION EQUIPMENT FOR STATIC TENSILE TESTS -- Strain gage data was acquired and recorded on a Model 256 Digital Data Acquisition System manufactured by B&F Instruments which provide read-outs of strain in microinches per inch and load in pounds. The extensometer was connected to the Autographic Recorder on the Tinius-Olsen test machine to provide a plot of load versus strain for determination of the 10-inch gage length yield stress.

5.5.2 DATA ACQUISITION EQUIPMENT FOR TENSILE FATIGUE TESTS -- Specimen strain gage signals were recorded on a Honeywell Visicorder Model 1580A oscillograph. Signal conditioning was provided by Validyne SG71 strain gage amplifiers and calibration signals by an EDC Model 2902 DC voltage calibrator. Single channel "quick look" capability was provided by a DANA digital voltmeter and/or a Tektronics memoscope.

Load cell readings were printed by the Teletype while testing under computer control; after the computer failure, the load cell output was monitored on the digital voltmeter and/or mem-o-scope.

5.5.3 DATA ACQUISITION SYSTEM FOR STATIC COMPRESSION TESTS -- All strain and deflection data was acquired and recorded on the Model 256 Digital Data Acquisition System manufactured by B&F Instruments which provided readouts of strain in microinches per inch and displacements in units of 0.001 inch. The Autographic Recorder of the Tinius-Olsen test machine was used to plot test machine head travel versus applied load.

5.6 TEST PROCEDURES

5.6.1 STATIC TENSION TESTS -- The specimens were installed in the test machine as described in Section 5.4.1 above. The strain gages were connected to the data system and the extensometer to the test machine autographic recorder. Prior to securing the specimen lower end fixture in the test machine wedge grips, i.e., with no load on the specimen, each strain gage bridge was balanced and resistance calibrated for direct data readout in engineering units. The strain gage zero and calibration data was recorded. The lower end fixture was then secured in the test machine wedge grips, and the autographic recorder was set to a zero reading.

Testing commenced at a loading rate of 150,000 pounds per minute with momentary "halts" at 10,000 or 20,000 pound intervals to record strain data. For the initial test, loading was applied to approximately 3/4 of the anticipated yield load, then released to zero to evaluate the extent of permanent deformation and/or hysteresis characteristics. Loading was then applied to the previous maximum load and incrementally increased to failure with all data recorded as before. For subsequent tests, the panels were loaded directly to failure with momentary halts to record data without intermediate returns to zero load.

After failure or "incipient" failure, the specimen was unloaded, instrumentation cables were disconnected, and the specimen was removed and photographed.

5.6.2 TENSILE FATIGUE TESTS -- For each test, the test specimen was installed in the test fixture and the strain gages were connected to the recording equipment, balanced, and resistance calibrated for data readout directly in engineering units. A static load survey to determine the stress distribution in each panel was made initially to assist in the determination of the cyclic load. This survey was required due to the uneven stress distribution caused by the varying degrees of specimen longitudinal bowing distortions. Using data obtained from the coupon tensile fatigue tests, a maximum cyclic load level was selected to initiate fatigue failure in the 100,000 to 1,000,000 cycle range. The test load upper limit was also selected to prevent yielding of the critical area determined by the static load survey. The test load lower limit was set to provide a stress ratio of 0.1. The load control system was programmed to cycle between the upper and lower load limits and fatigue cycling was started. At the beginning of each test, the load cell and strain gage readings were monitored, at low frequency cycling, to verify the loads and strains. After this verification, the frequency was slowly increased to maximum attainable without degradation of the desired sinusoidal waveform.

The panel specimen was visually inspected every 10,000 or 20,000 cycles using a drop light and magnifying glass as required. These inspections were performed while the maximum cyclic load was maintained constant in order to enhance the visibility of any cracks, etc. Dye penetrant was utilized to clarify areas of uncertainity remaining after visual examination. The oscillograph was activated at approximately 5,000 cycle intervals to check if change had occurred in any of the strain gage readings. A change in the output from a strain gage proved to be one of the better indicators of internal damage to the specimen. Cycling and inspections were continued in this manner until a crack was detected. When a crack was discovered, the extent of the crack was

noted and cycling was continued with periodic halts as frequently as 5,000 cycles to measure the extent of crack propagation. This procedure was continued until complete failure was imminent or actually occurred. If no cracks were detected, testing continued with normal inspection intervals to "run-out" at 1,000,000 load cycles. Photographs were taken of each specimen at the conclusion of testing.

A crack-wire installation was explored in an attempt to detect crack initiation earlier than by visual observation. Trial installations were made on three specimens, but the results were disappointing and the effort was discontinued.

5.6.3 STATIC COMPRESSION TESTS -- For each test, the test specimen was installed in the end fixtures mounted in the test machine. The strain gages were connected to the data system and the deflection transducer lead wires were clipped to the specimen mounting tabs. With slight clearance maintained at the test machine upper head, i.e., no load on the specimen, each strain gage bridge was balanced and resistance calibrated for direct readout of strain in microinches per inch. The measurement span of each of the deflection transducers was calibrated, using standard gage blocks, for direct readout of displacements in units of 0.001 inch. The test fixture upper pin was aligned and an axial preload of up to 5000 pounds was applied to hold the specimen properly aligned. All of the deflection transducers were balanced to indicate zero deflection on the data system at this preload. Testing was then commenced at a loading rate of 100,000 pounds per minute with "halts" at 10,000 or 20,000 pound intervals to record the strain and deflection data. For each specimen, the loading was continued to approximately 75 percent of the anticipated buckling load after which the load was returned to the 5000 pound, preload level and data was again recorded to evaluate the extent of permanent deformation and/or hysteresis characteristics. Loading was then increased to the previous maximum load and the test was continued to failure recording data at intervals as before. Loading was continued beyond instability to

clearly define the manner of buckling; in most cases, the load was then returned to the preload level and reapplied to evaluate the "post-buckling" residual strength.

The specimen was then unloaded, instrumentation cables were disconnected and the specimen was removed and photographed.

5.7 STIFFENED PANEL SPECIMEN TEST RESULTS

5.7.1 STATIC TENSION TESTS

5.7.1.1 Results -- Four specimens of two configurations were tested in static tension and the results are presented in Table 5-4. Autographic plots of load-strain curves and complete tabulations of all strain data obtained from the stiffened panel static tensile tests are provided in Section 1 of Appendix D. Stress-strain plots and photographs of one specimen of each panel configuration are presented in Figures 5-19 through 5-21.

Table 5-4. Results of Stiffened Panel Static Tension Tests

Specimen No.	Minimum Area (in^2)	Yield Data (10" Gage Length)		Ultimate Data		Notes
		Load (kips)	Stress (ksi)	Load (kips)	Stress (ksi)	
TT802022-3-S1	6.258	200.0	32.0	245.0	39.2	(1),(3)
-3-S2	6.310	213.8	33.9	302.0	47.9	(1),(4)
-201-S1	6.205	208.0	33.5	245.5	39.6	(2),(5)
-201-S2	6.230	197.5	31.7	249.0	40.0	(2),(5)
Average			32.8		(6)	

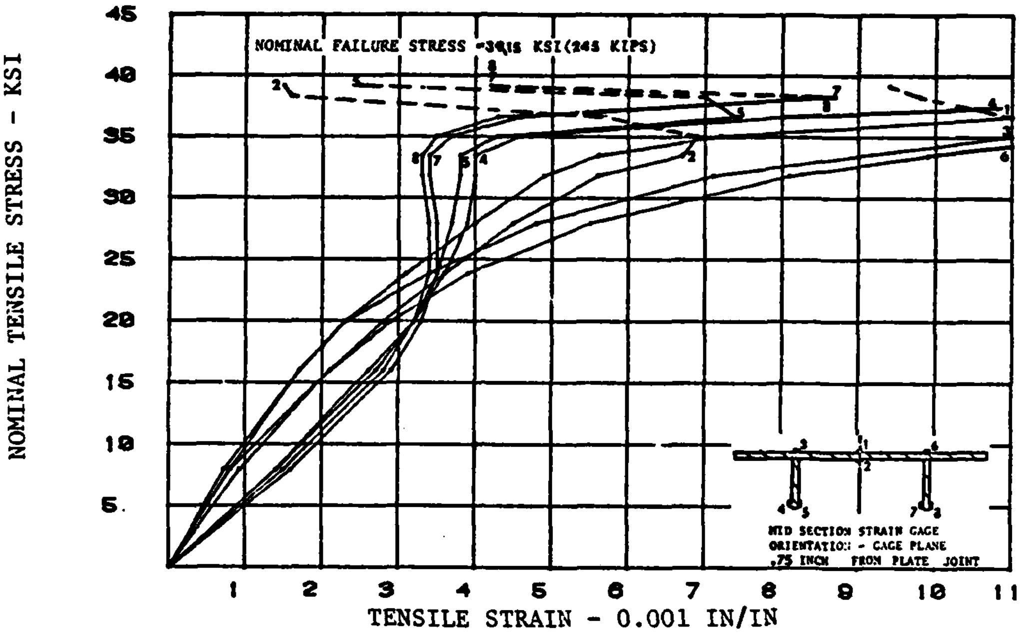
Notes.
1) Erection Joint panel with stiffeners joints butt welded
2) Erection joint panel with doublers riveted over unwelded stiffener butt joints.
3) Failure initiated in defective weld in stiffener butt joint.
4) No failure; testing machine capacity was 300 kips
5) Stiffener failure in rivet holes at the end of the doubler.
6) Average ultimate stress is not meaningful due to differences in design and failure modes.

One of the baseline specimens with welded stiffener joints (TT802022-3-S1) failed slightly below the 40 ksi welded material ultimate tensile strength. The failure initiated at a weld defect (lack of fushion) located in a stiffener butt joint near the stiffener plate intersection. This joint had been repaired, and the lack-of-fusion was not detected by post-repair radiographic inspection. Although failure initiated at the weld defect, the failure was influenced by the stress distribution resulting from the specimen distortion (see Table 5-3 and the discussion in Paragraph 5.7.1.2 below.) The other baseline specimen with welded stiffener joints (TT802022-3-S2) exhibited strength in excess of the rated capacity of the test machine.

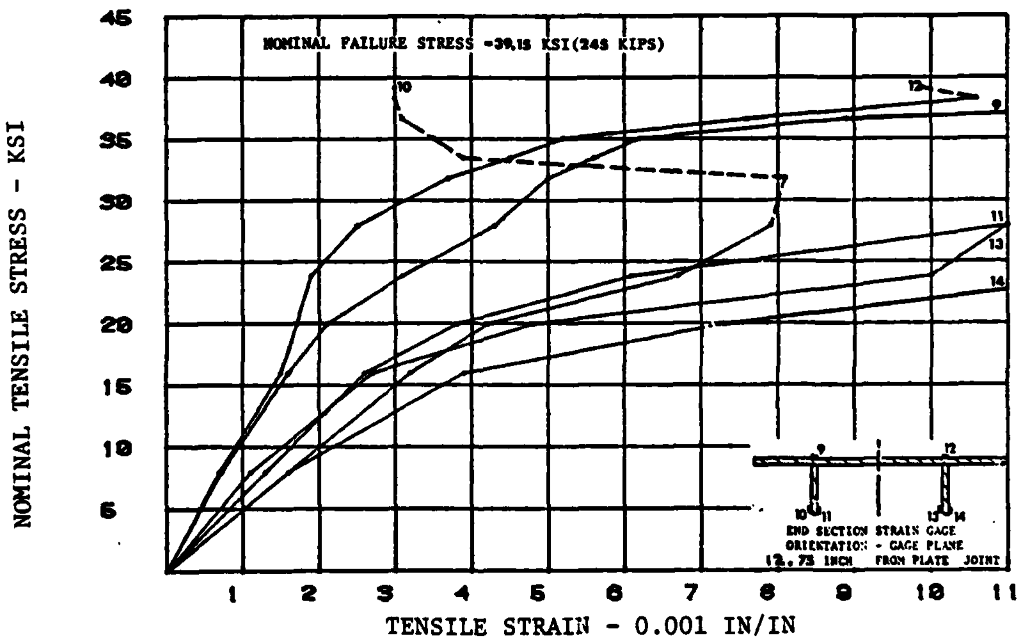
Each of the specimens with doublers riveted over unwelded stiffener joints failed through a rivet hole in the stiffener nearest the end of the doubler. Failure initiation was attributed to the reduction of stiffener cross-section area due to the rivet hole.

5.7.1.2 Discussion of Results -- The stress-strain plots presented in Figures 5-19 and 5-20 are similar to those reported in the H-5 Advanced Development Program Test Reports (References 5 and 6). Strain gages located over weld heat affected zones (HAZ), i.e., gages 1-3 and 6 at the panel mid-section and gages 10, 11, 13 and 14 at the end section of welded stiffeners (TT802022-3 specimens), exhibited local yielding at stress levels below the panel nominal yield stress. Other gages in areas remote from the HAZ exhibited yielding at stresses above the panel nominal yield stress.

The minimum ultimate tensile strength of the stiffened panels was less than the average ultimate strength of comparable coupon specimens shown in Figure 4-14. The lower strength of the stiffened panel specimens, as compared to the coupon data, was attributed to panel distortions and a lack-of-fusion weld defect. The average of the measured panel yield stress was comparable to the minimum stress of unwelded 5456-H116 material and was approximately 26% greater than the allowable stress (26 ksi) for as-welded material.

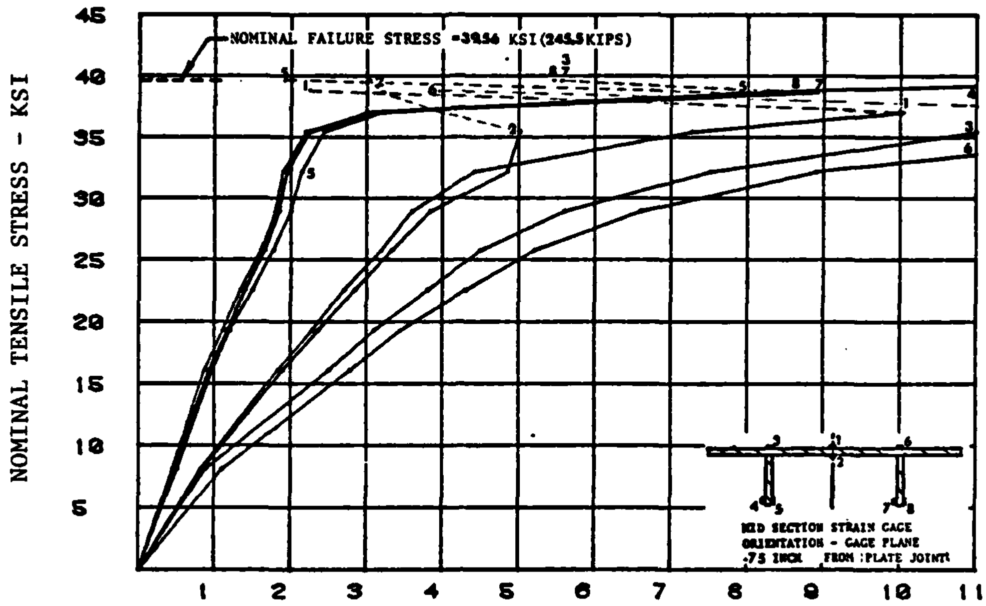


a) Strain Gages at Panel Mid-Section.

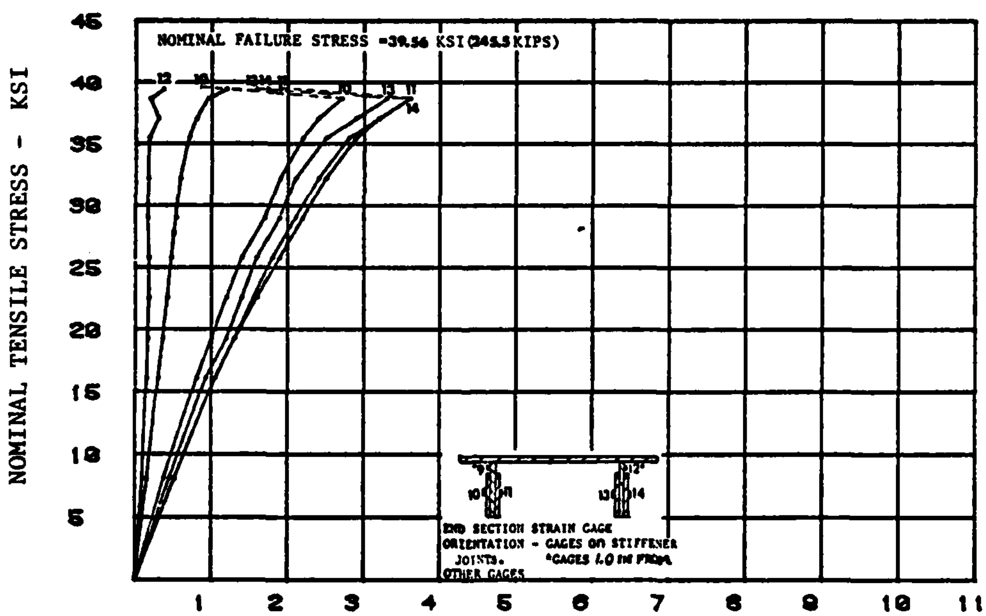


b) Strain Gages near Stiffener Butt Joints.

Figure 5-19. Stress-Strain Curves for Stiffened Panel Static Tensile Test Specimen TT802022-3-S1 (Baseline).



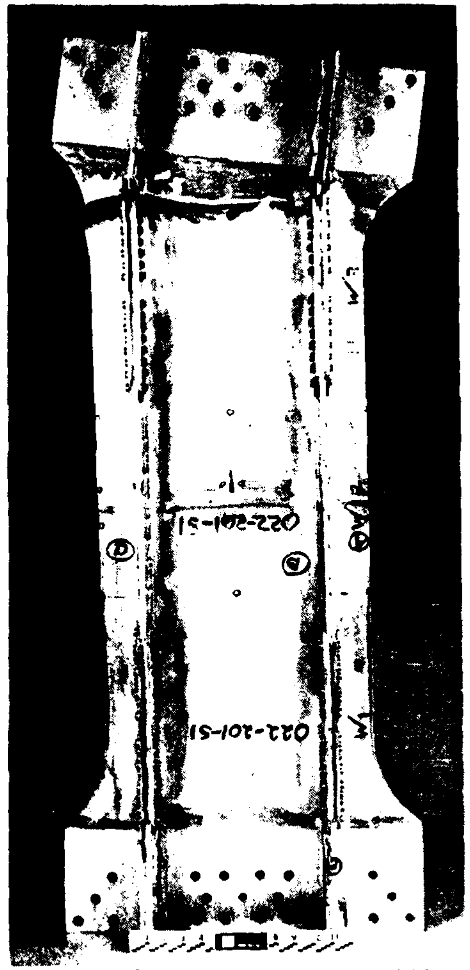
a) Strain Gages at Panel Mid-Section.



b) Strain Gages near Stiffener Butt Joints.

Figure 5-20. Stress-Strain Curves for Stiffened Panel Static Tensile Test Specimen TT802022-201-S1 (Riveted Stiffener Joints).

(a) (790085-3) Specimen No. TT802022-3-S1
Baseline.



(b) (790085-5) Specimen No. TT802022-201-S1
Riveted Doublers Over Unwelded
Stiffener Joints.

Figure 5-21. Typical Stiffened Panel Static Tension Test Specimens After Failure.

Comparison of the stiffened panel static tensile results from the present program with those fram the H-5 Advanced Development Program as reported in Reference 5, are presented in Table 5-5. The H-5 panel test specimens differed from the current test specimens in that extruded T-stiffeners were used and the stiffener butt joints were coincident with the plate butt joint resulting in a total heat affected cross section. Because of staggered stiffener and plate weld joints, the current specimen yield strength was improved over the H-5 specimens; ultimate strength was also improved compared to the H-5 specimens.

Table 5-5. Comparison of Panel Static Tensile Average Test Results with H-5 Program Average Test Results

SPECIMEN NO.S	PANEL YIELD STRESS (ksi) (2)	PANEL ULTIMATE STRESS (ksi) (3)	SPECIMEN QUANTITY
TT802022-3 & -201	32.8	39.2 (4)	4
H5 ADP SPMS(1)			
No offset	28.5	38.0	3
0.09-0.13 offset	25.6	34.1	5

Notes:

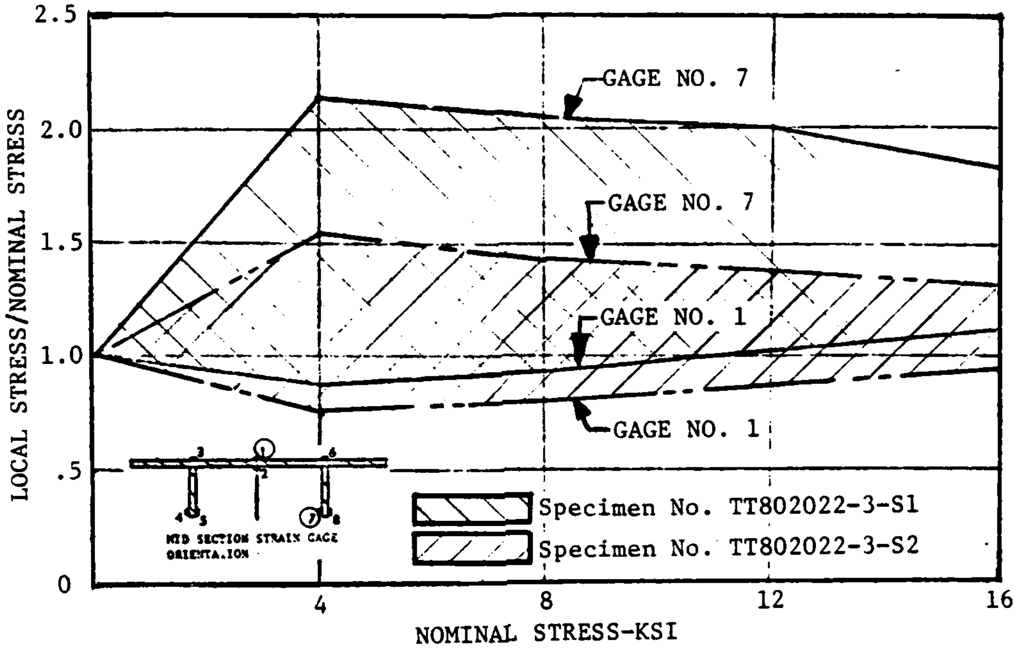
(1) Average data for erection joints with transverse welds, with and without weld joint offset, as shown in Table 3-1 of Reference 5.

(2) Yield strength obtained from load-elongation curve using 10-inch gage length extensometer centered on panel mid-section and actual cross-section area.

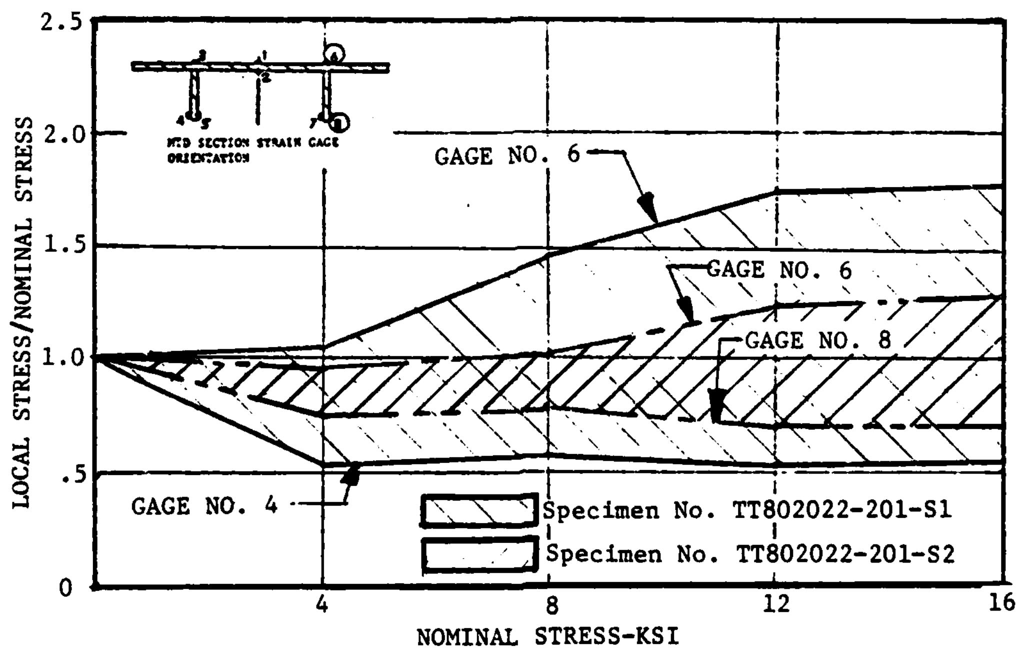
(3) Ultimate stress determined from failure load and actual cross-section area.

(4) Minimum value since only 1 of 4 specimens tested failed in the reduced area section.

The effects of panel distortion are illustrated by the stress envelopes plotted in Figure 5-22. Each stress envelope compares the maximum and mininum local stresses with nominal stress at the specimen mid-section for nominal stresses below the proportional limit. These envelopes illustrate the differences in stress distribution due to distortion for each type of panel configuration. Panels with welded stiffeners were slightly kinked at the stiffener butt joints, and the resulting panel eccentricity increased stiffener free edge stresses due to bending.



a) Baseline Specimens.



b) Specimens with Riveted Doublers Over Unwelded Stiffener Joints.

Figure 5-22. Local Stress Magnification Factor Envelopes for Stiffened Panel Static Tensile Tests.

This effect was reversed on the panels with riveted stiffener joints. These panels were essentially straight as fabricated, and the load distribution peaked on the plate due to the less efficient load transfer by the mechanical fasteners in the stiffener joints.

5.7.2 TENSILE FATIGUE TESTS -- Results from the stiffened panel tensile fatigue tests are summarized in Table 5-6 and shown graphically as S-N data in Figure 5-23. The S-N envelopes shown in Figure 5-23 were defined by theoretically derived S-N curves drawn through the lowest and highest data points for each specimen type as previously described in Section 4.7.1.2. Fatigue strength comparisons at 500,000 cycles endurance are presented in Figure 5-24. Extropolation of the S-N envelopes beyond the actual test data was necessary for certain specimen configurations to define the data band at 500,000 cycles.

Comparison of the stiffened panel fatigue strength results with the butt welded plate coupon fatigue data for 0.313 inch thick specimens (Reference Section 4) indicates a substantially lower fatigue strength for the panels. Baseline, mismatch, and single/multiple repair panels exhibited fatigue strengths ranging between 53 and 66 percent of the comparable coupon strengths at 500,000 test cycles. Causes for these strength reductions are discussed below.

Stress magnification factors determined from the strain survey static tests conducted on most panel specimens prior to the start of fatigue testing are shown in Figure 5-25. Generally, this survey was conducted only for panels with high longitudinal eccentricity on which additional strain gages were installed. The range of local to nominal stress ratio varied from 0.98 to 2.76. Complete strain gage data recorded from the static surveys is provided in Section 2 of Appendix D. Discussions of the results from each panel configuration group of specimens follow below.

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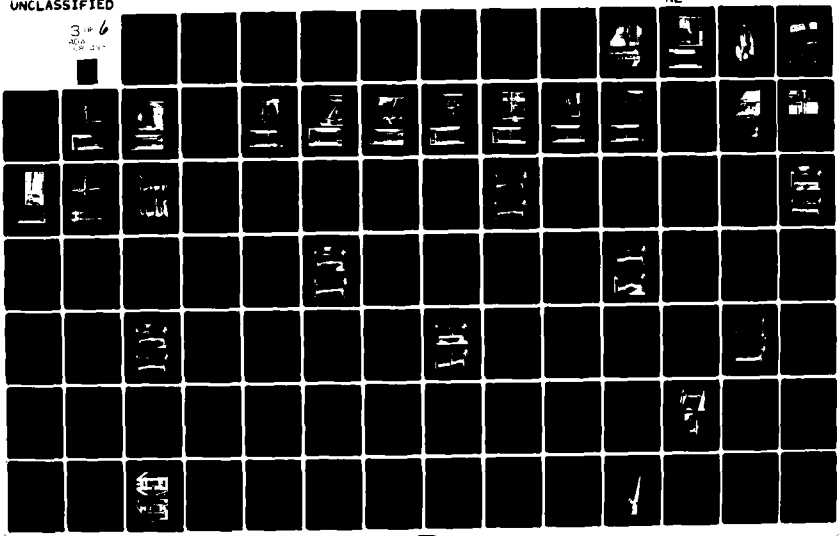


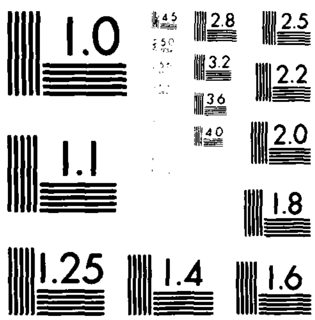

1.0
4.5
5.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

Table 5-6. Flatbar Stiffened Panel Fatigue Test Results Summary.

SPECIMEN DESCRIPTION				TEST NOMINAL STRESS (R = 0.1)		RESULTS			
Type/Processing	Specimen No. TT802022	Weld Assy No. TT802024	Min. Cross Sect. Area (in.^{2})	Max. KSI	Min. KSI	Test Cycles: Crack Noted	Test Cycles: Test Complete	Crack Location	Final Specimen Condition
Baseline - as welded	-3-F1	-1	6.316	10.0	1.0	249,800	249,800	Stiff. butt weld toe	Stiff. fracture
	-3-F2	-1	6.292	7.2	.72	340,210	348,810	Stiff. butt weld toe	Stiff. fracture
	-3-F3	-1	6.304	9.0	.9	none	1,000,000	No observed failure	Run-out
Straightened after longitudinal bowing until stiffeners buckled.	-5-F1	-9	6.203	13.5	1.35	140,000	151,430	Plate butt weld toe (2 cracks)	Panel fracture
	-5-F2	-9	6.245	11.0	1.1	280,000	305,610	Stiff. butt weld toe and fillet weld (2 cracks)	Panel fract.at fillet
Mismatched plate and stiffener butt joints plus flap peen processing. △1	-11-F1	-41	6.279	8.0	.8	170,000	176,370	Plate butt weld toe (re-entrant angle)	Panel fracture △3
	-11-F2	-41	6.263	7.0	.7	420,000	433,500	Plate butt weld toe (re-entrant angle)	Panel Fracture △3
	-11-F3	-41	6.316	8.0	.8	660,000	684,760	Stiff. butt weld (no re-entrant angle)	Stiff. fracture
Single weld repairs in plate and stiffener butt joints plus flap peen processing at some locations. △2	-103-F1	-51	6.325	10.0	1.0	320,000	322,970	Stiff. butt weld toe (not peened)	Stiff. fracture
	-103-F2	-51	6.345	9.0	.9	420,000	456,910	Stiff. butt weld (not peened)	Panel fracture △3
	-103-F3	-51	6.302	9.0	.9	664,970	655,200	Stiff. fillet weld overlap (not peened)	Panel fracture
Multiple weld repairs in plate and stiffener butt joints plus flap peen at some locations. △2	-107-F1	-53	6.344	10.0	1.0	197,070	219,110	Stiff. butt weld (not peened)	Stiff. fracture △3
	-107-F2	-53	6.311	9.0	.9	225,000	230,000	Stiff. butt weld toe (not peened)	Stiff. fracture
	-107-F3	-53	6.311	8.0	.8	835,000	875,890	Plate butt weld toe (not peened)	Panel fracture
Doublers adhesively bonded over single weld repairs in plate and one pair of stiffener butt joints.	-205-F1	-57	6.316	11.0	1.1	280,000	324,890	Stiff. butt weld toe (w/o repair)	Panel fracture △3
	-205-F2	-57	6.306	9.0	.9	260,000	340,000	Stiff. butt weld toe (w/o repair)	Stiff. fracture △3
	-205-F3	-57	6.318	10.0	1.0	480,000	507,370	Stiff. butt weld toe (w/o repair)	Panel fracture △3
Doublers riveted over single weld repairs in plate and one pair of stiffener butt joints.	-203-F1	-63	6.317	11.9	1.19	143,510	143,680	Stiff. rivet hole	Stiff. fracture
	-203-F2	-63	6.351	7.9	.79	506,290	506,680	Stiff. rivet hole	Stiff. fracture
	-203-F3	-63	6.342	7.9	.79	440,000	501,480	Stiff. butt weld at repair	Panel fracture △3
Doublers riveted over unwelded stiffener butt joints	-201-F1	-59	6.298	9.5	.95	483,510	485,620	Stiff. rivet hole	Panel fracture △3
	-201-F2	-59	6.295	11.0	1.1	280,000	289,560	Stiff. rivet hole	Stiff. fracture
	-201-F3	-59	6.277	13.5	1.35	36,700	37,110	Stiff. fillet weld	Sudden panel fract. △3

NOTES: △1 All butt weld surfaces flap peened.
△2 For specific specimen repair and processing information, see Section 5.2.1.2.
△3 Abnormality at fatigue origin (e.g. excess porosity, lack of fusion/penetration, weld toe re-entrant angle).

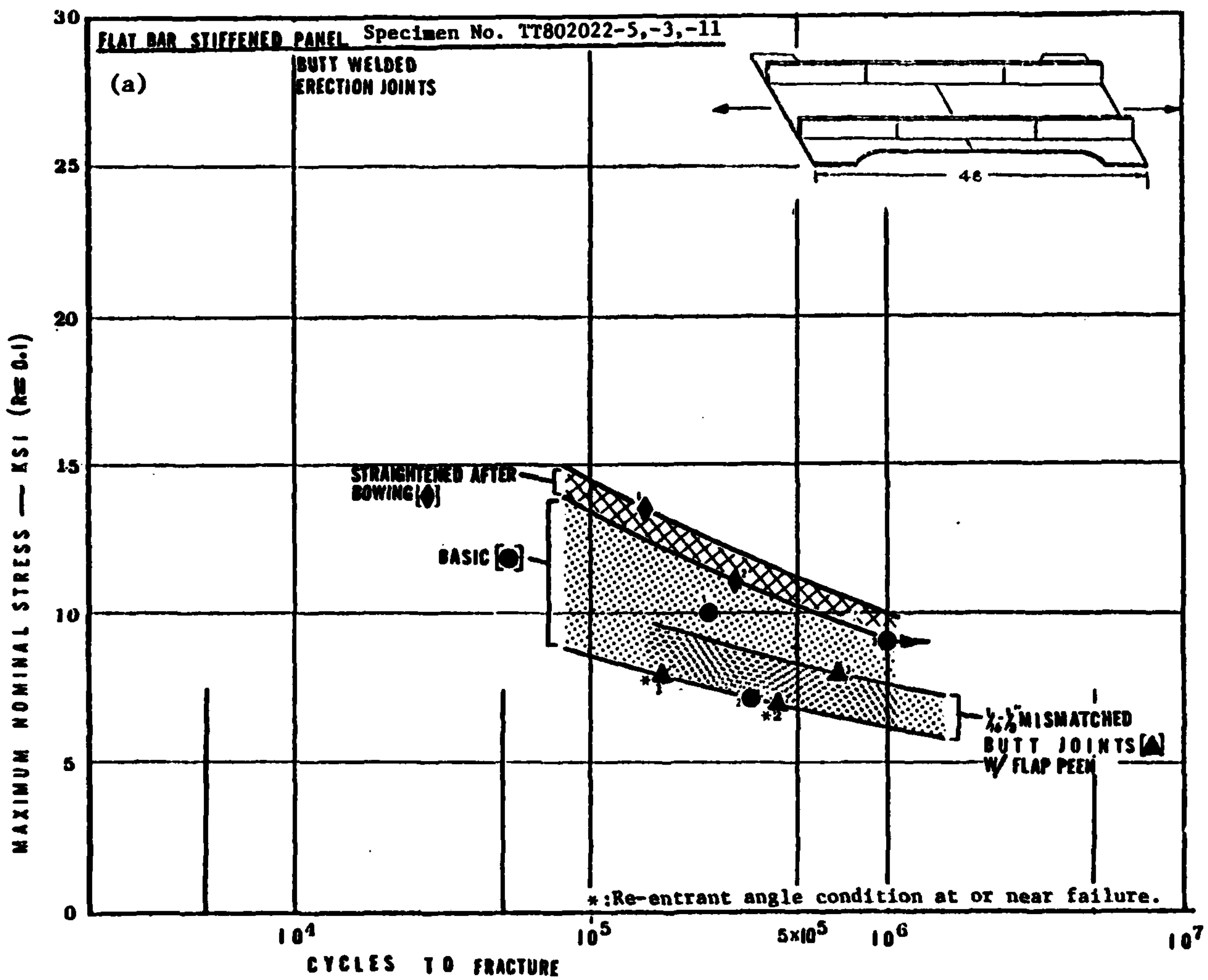


Figure 5-23. Stiffened Panel Fatigue Test Results (Sheet 1 of 3).

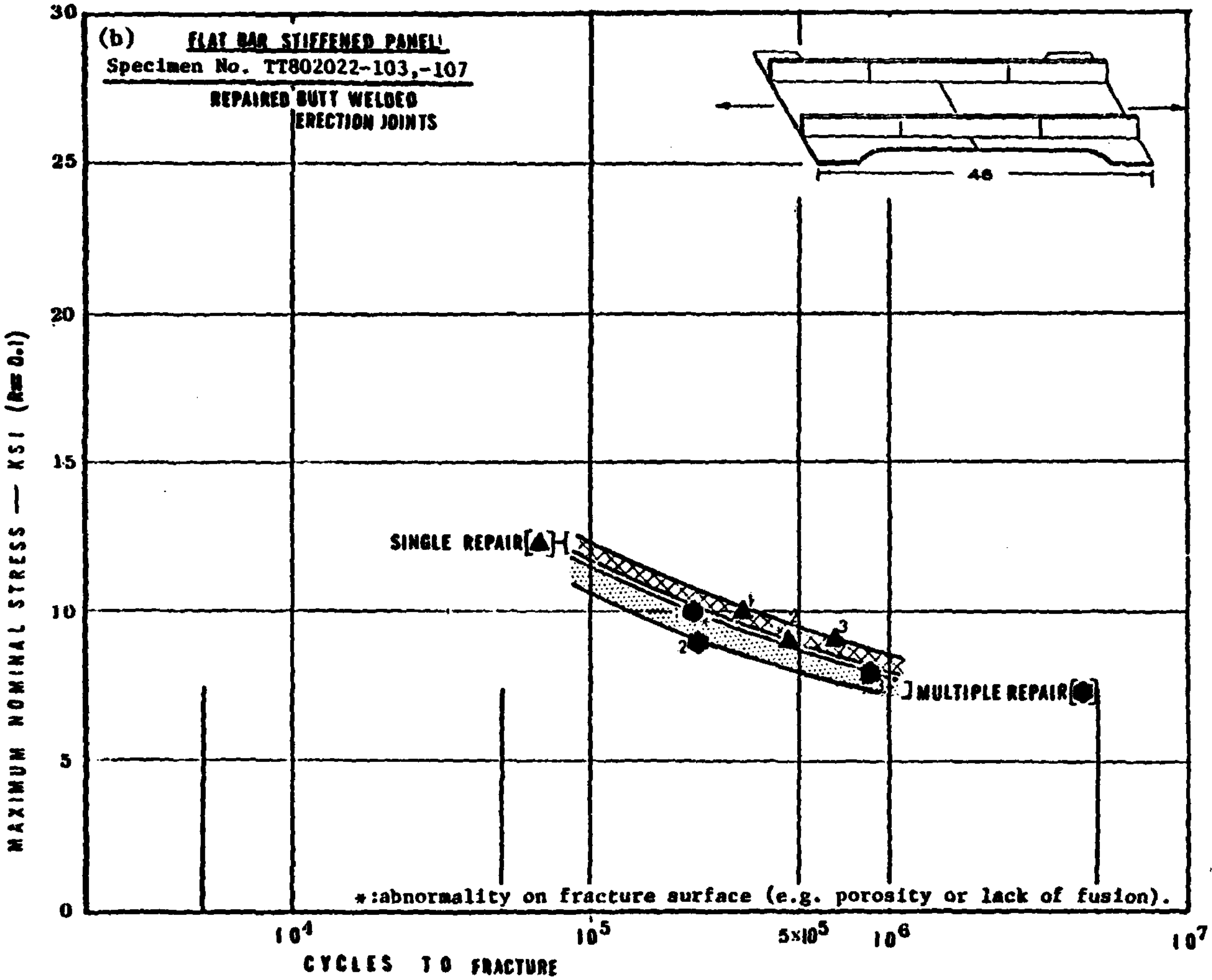


Figure 5-23. Stiffened Panel Fatigue Test Results (Sheet 2 of 3).

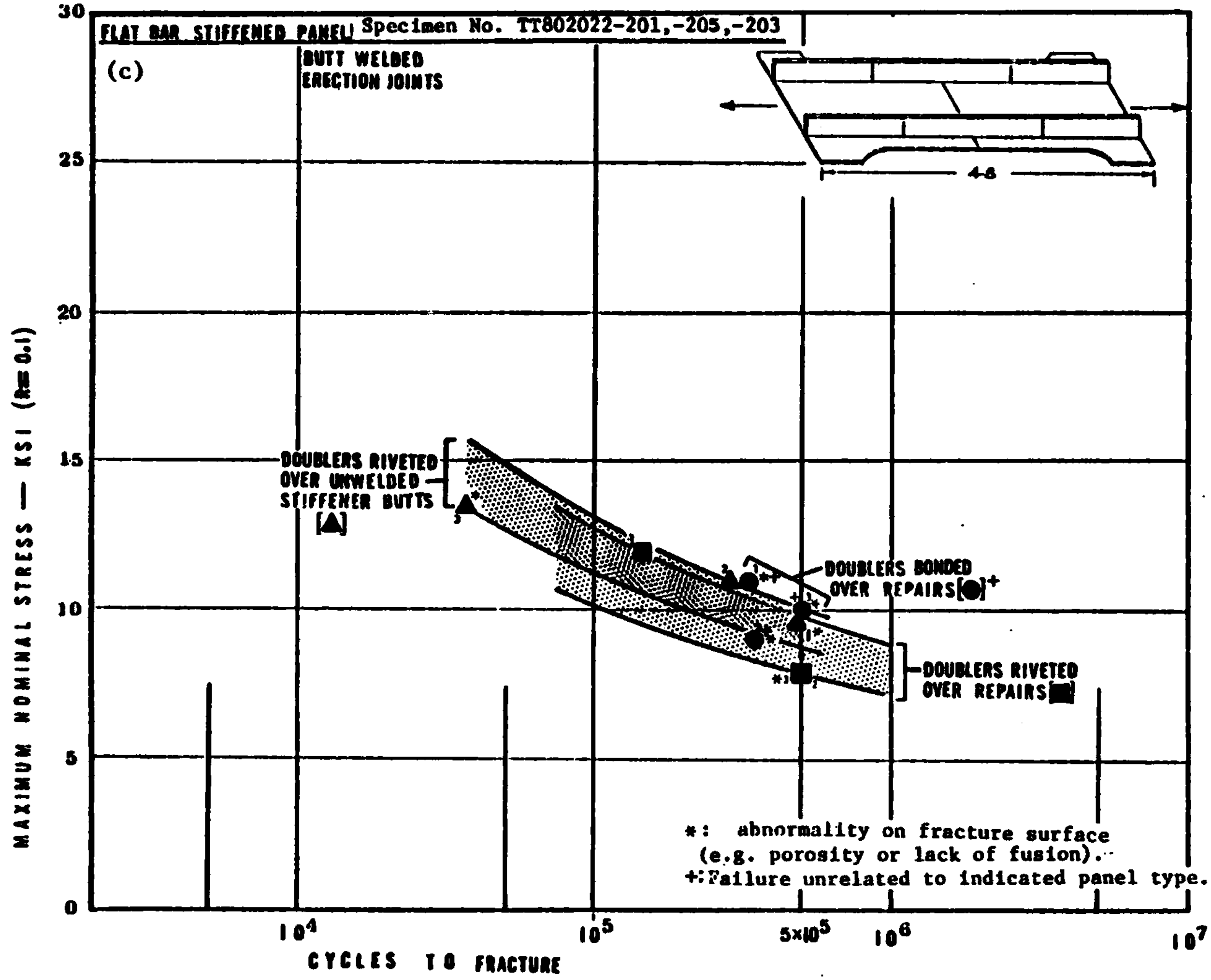
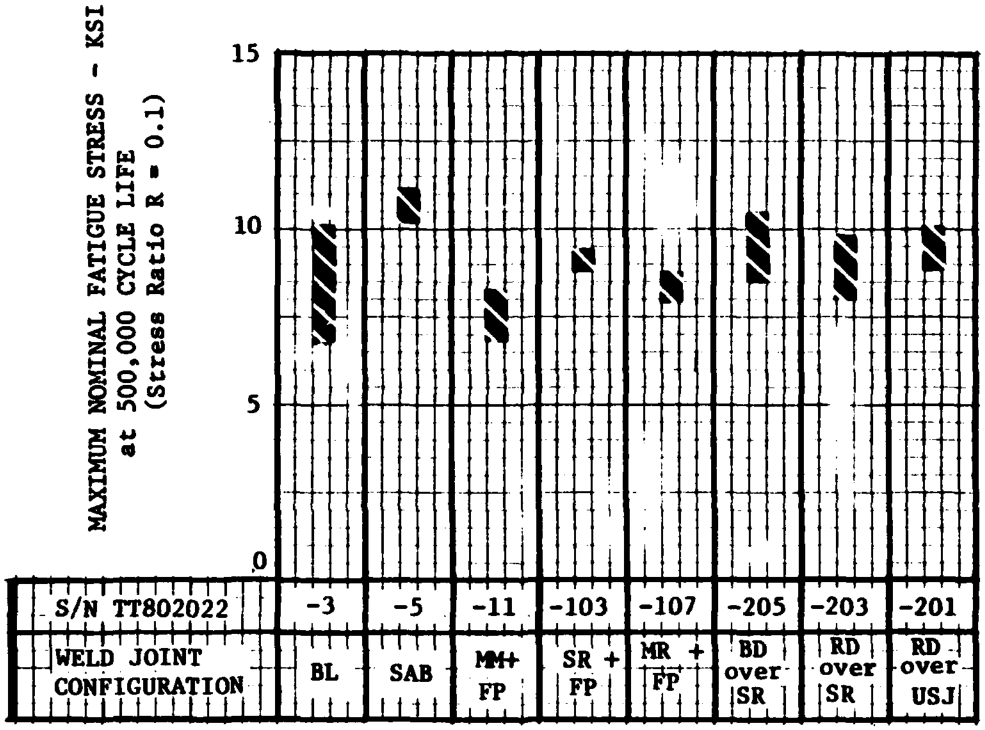


Figure 5-23. Stiffened Panel Fatigue Test Results (Sheet 3 of 3).



Legend: = Data Range; BL = Baseline; SAB = Straightened After Bowing; MM = Mismatch; FP = Flap Peen; SR = Single Repair; MR = Multiple Repair; B = Bonded; D = Doublers; R = Riveted; USJ = Unwelded Stiffener Joints.

Figure 5-24. Stiffened Panel Fatigue Strength Comparisons at 500,000 Cycles Endurance.

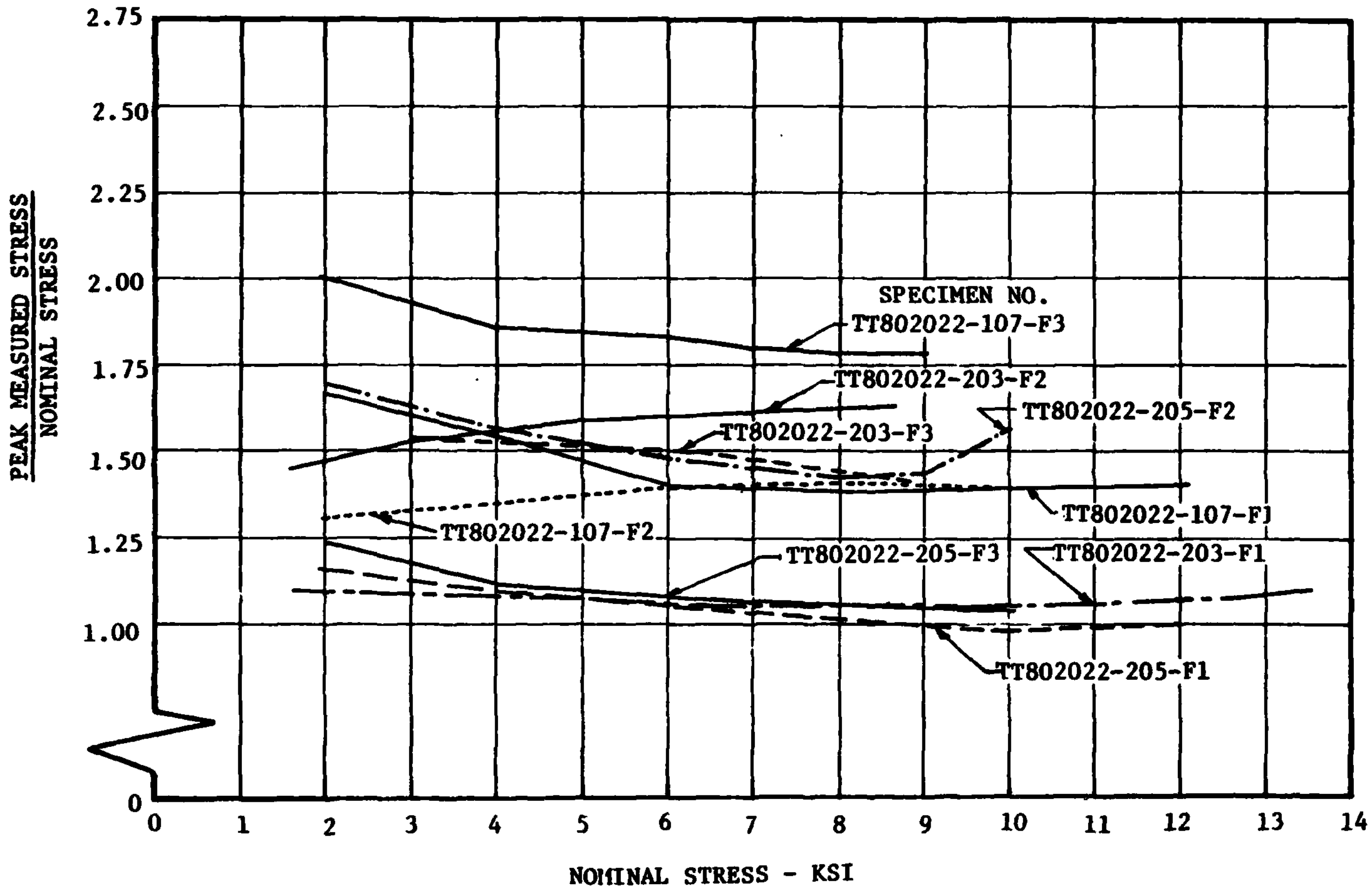


Figure 5-25. Measured Static Stress Magnification Factors for Stiffened Panel Fatigue Test Specimens. (Sheet 1 of 2).

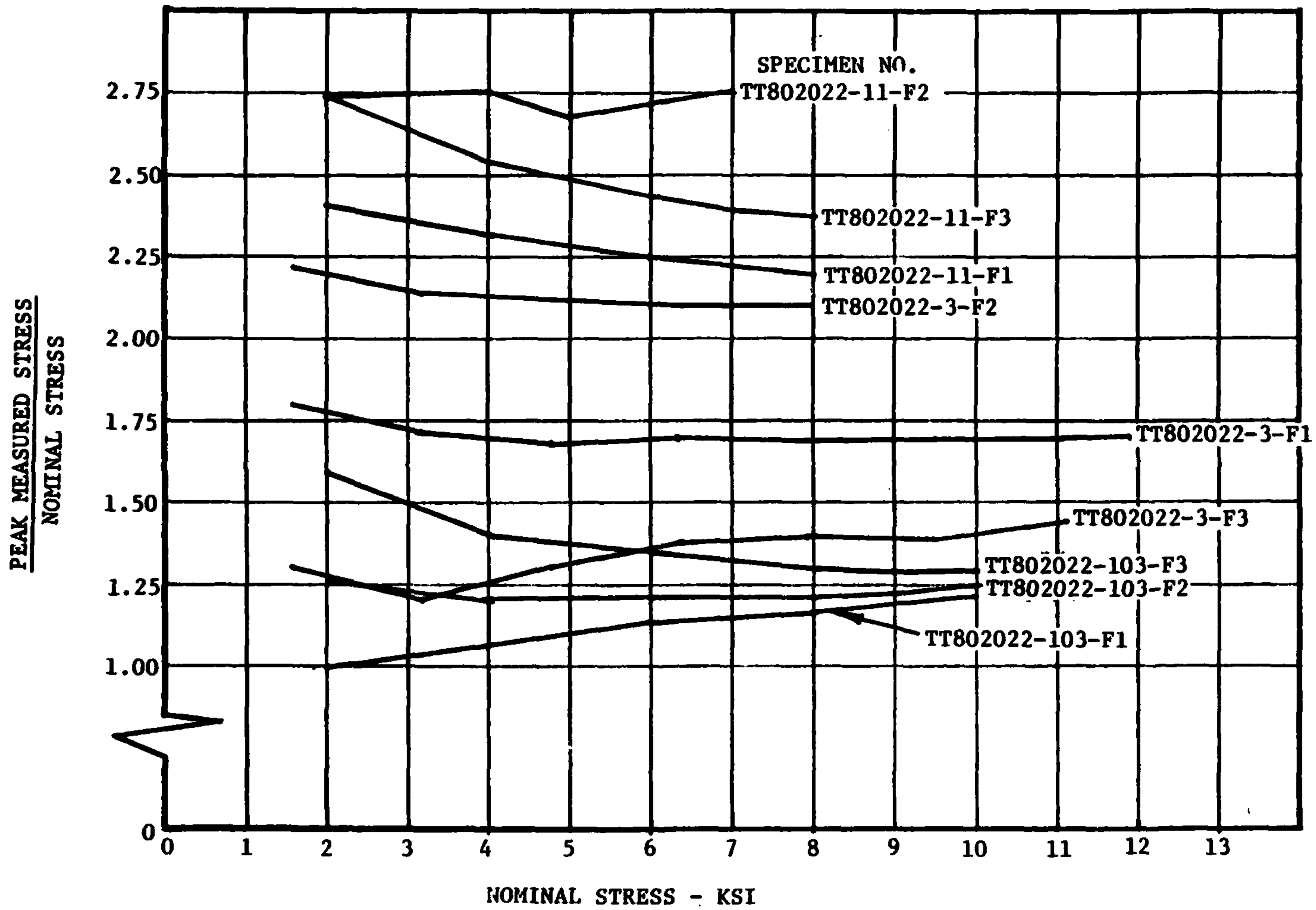


Figure 5-25. Measured Static Stress Magnification Factors for Stiffened Panel Fatigue Test Specimens. (Sheet 2 of 2).

a. Specimens TT802022-3F2,-F2,-F3 (Baseline): A considerable strength variation was encountered in the three panel specimens with two stiffener butt weld failures and one run-out (one million cycles without failure). Strength differences were attributed to butt weld toe angle variations and panel longitudinal eccentricity.

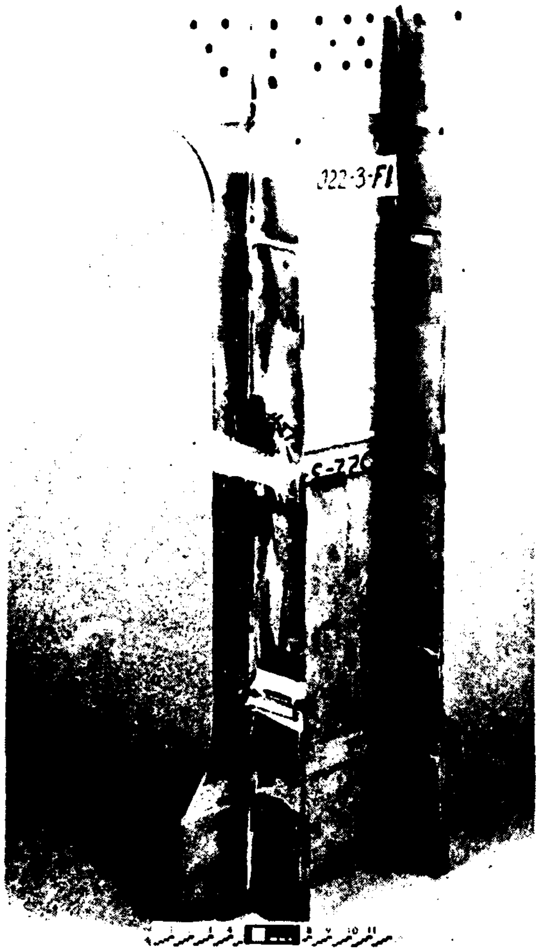
   Failure of the second specimen established the low strength envelope boundary for all panels tested. This specimen contained an excessively large and steep sided butt weld reinforcement at the fatigue origin plus the largest longtiudinal eccentricity measured.

   Photographs of the two baseline specimens which failed in fatigue and the respective failure origins are shown in Figure 5-26 and 5-27.

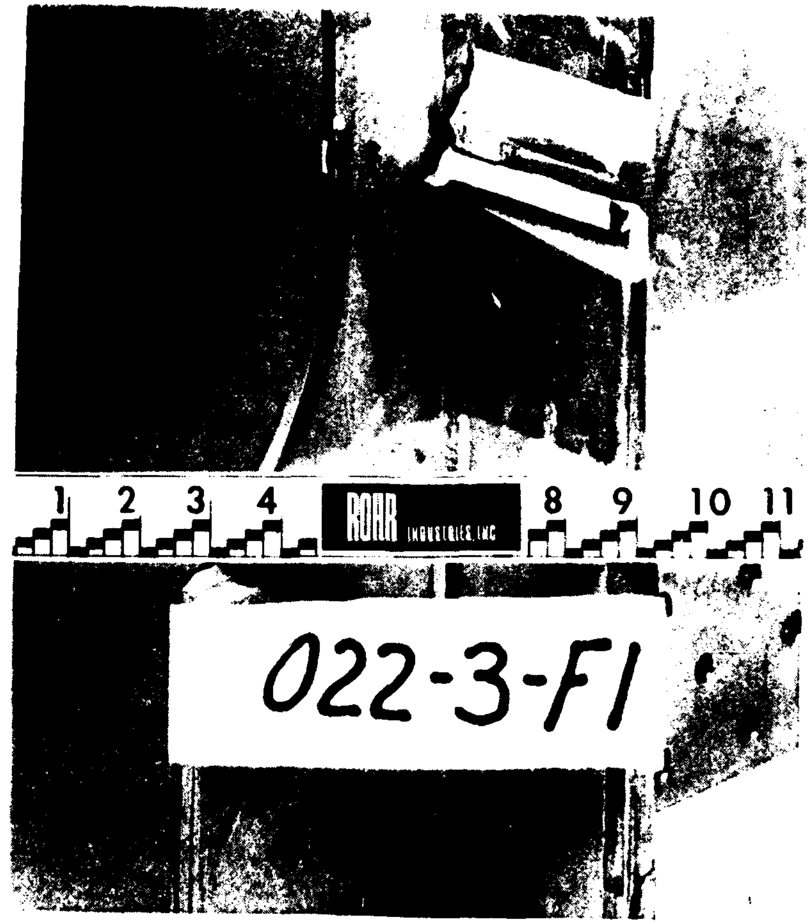
b. Specimens TT802022-5-F1,-F2 (Straightened after longitudinal bowing): These two specimens demonstrated the highest fatigue strength of all panels tested. Higher strength was primarily attributed to the low panel longitudinal eccentricity; Strain hardening incurred during the straightening process may have been a secondary contributing factor.

   The two Failures in the straightened specimens initiated in the deck plate butt weld and a stiffener butt weld as shown in Figure 5-28 and 5-29.

c. Specimens TT802022-11-F1,-F2,-F3 (Mismatched butt joints with flapper peening post-weld processing): These specimens exhibited among the lowest panel fatigue strengths. Two of the three specimens tested failed in the deck plate butt weld with origins at weld root re-entrant angle on the deck surface. (Peening was inadvertantly omitted on the side of the deck butt weld opposite the stiffener.) Bending stresses due to the plate joint mismatch were compounded by this re-entrant angle condition.

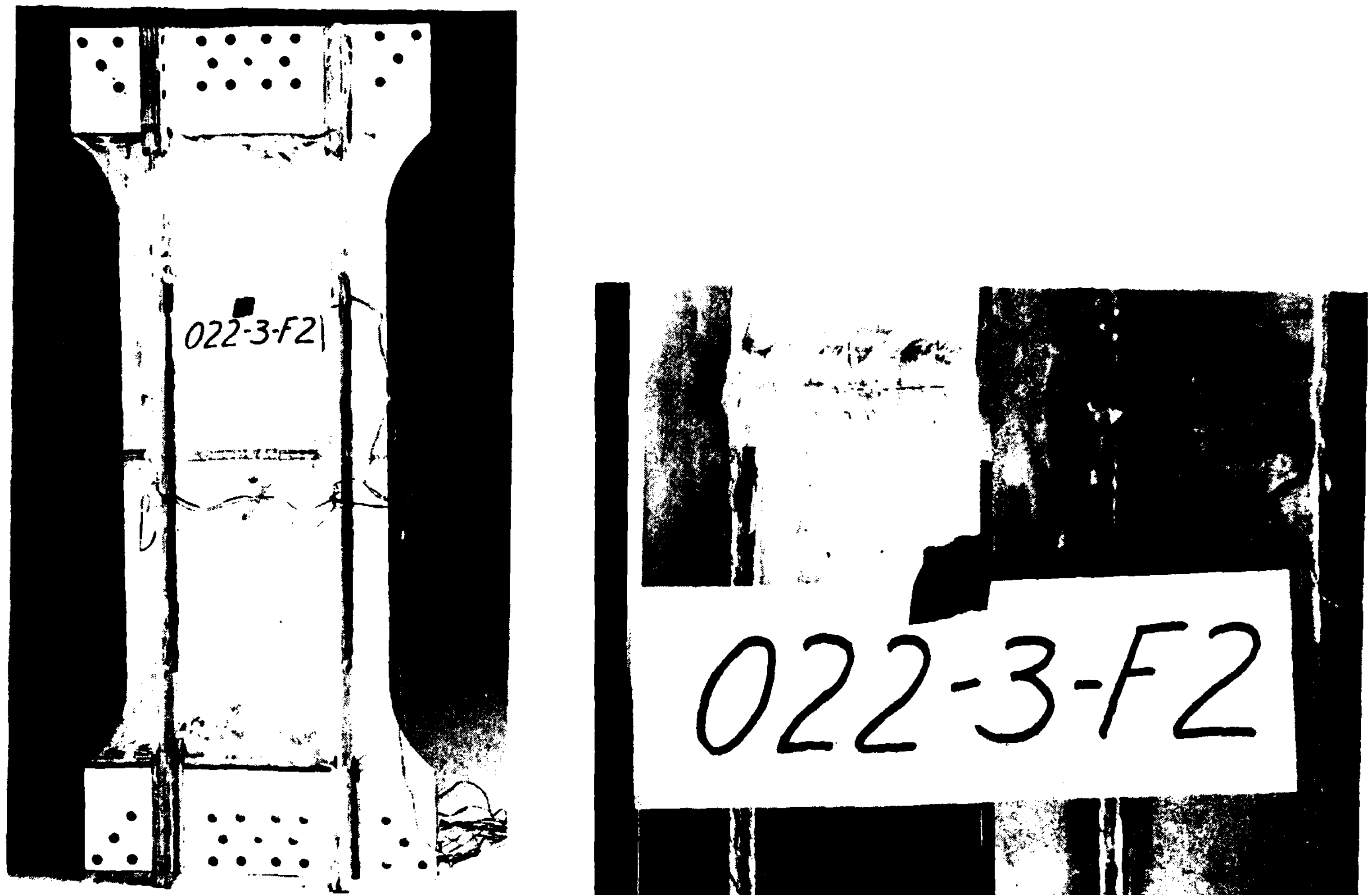


(a) (790153-3) Speciment Overall View



(b) (790153-2) Stiffener Butt Weld Failure Detail
(Cut free to show fracture surfaces)

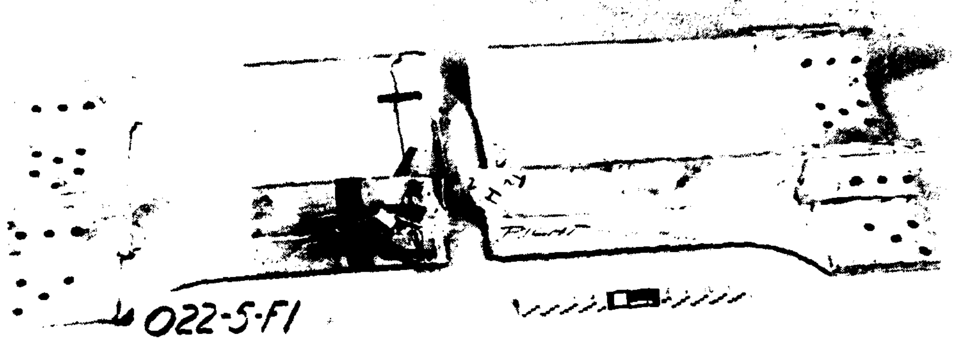
Figure 5-26. Stiffened Panel Fatigue Test Specimen No. TT802022-3-F1
(Baseline) After Failure.



(a) (790859-6) Specimen Overall View

(b) (790859-15) Stiffener Butt Weld Failure Detail

Figure 5-27. Stiffened Panel Fatigue Test Specimen No. TT802022-3-F2 (Baseline) After Failure

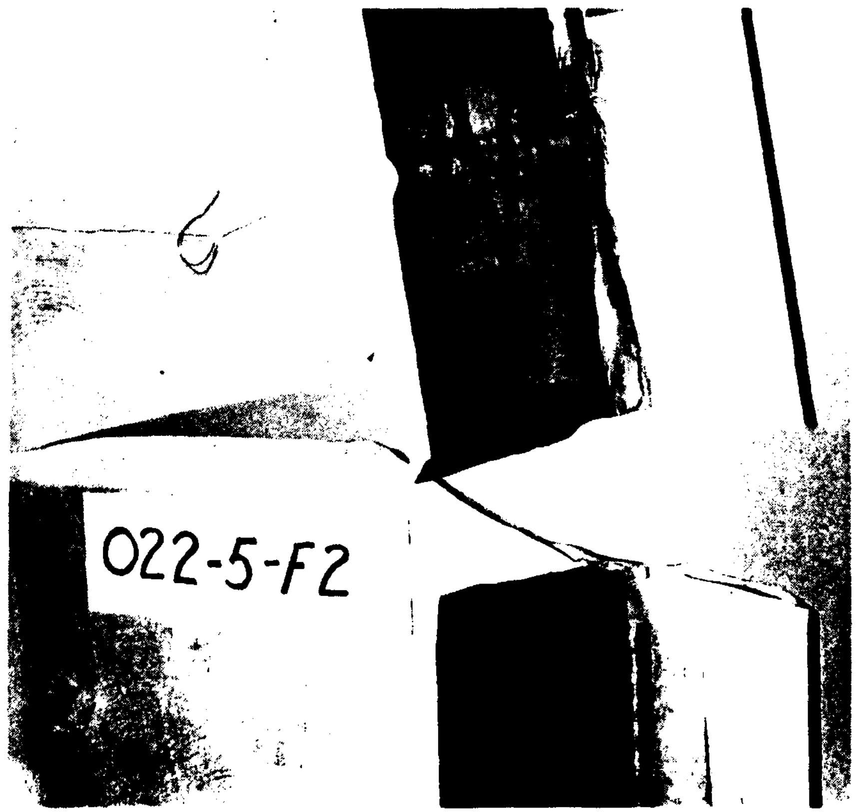


(a) (790152-1) Specimen Overall View

(b) (790152-4) Plate Butt Weld Failure Origin

Figure 5-28. Stiffened Panel Fatigue Test Specimen
No. TT802022-5-F1 (Straightened) After Failure

(a) (790308-6) Specimen Overall View



(b) (790308-2) Detail of Stiffener Fillet Weld Fracture Origin

Figure 5-29. Stiffened Panel Fatigue Test Specimen No. TT802022-5-F2 (Straightened) After Failure

A significant strength improvement was achieved by removal of the weld reinforcement re-entrant condition on the third specimen. Removal of the reinforcement roll-over was accomplished by hand fairing the reinforcement to the plate surface producing an acceptable production quality mismatched weld. The faired deck reinforcement was not flap peened to provide a strength comparison with the first two specimens. This processing induced the higher strength stiffener butt weld failure mode.

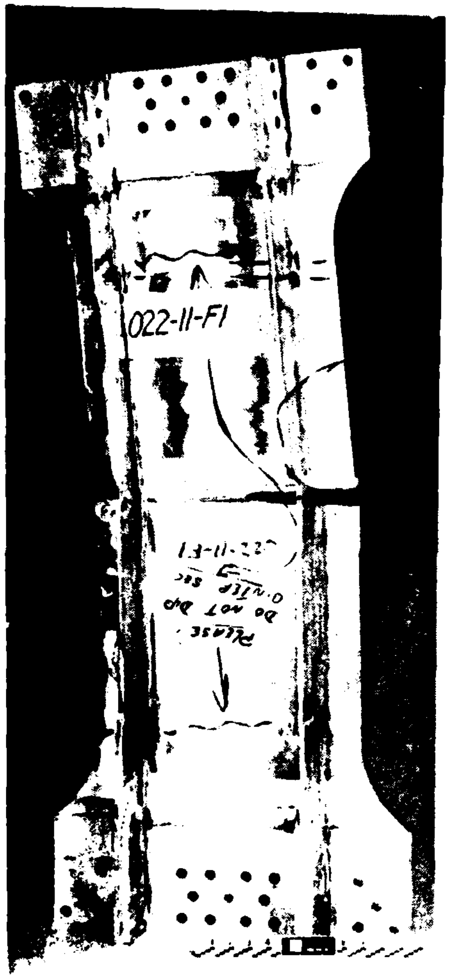
Failure mode photographs are shown in Figure 5-30 and 5-31. Failures in replicates -F1 and -F2 were essentially identical in nature.

d. Specimens TT802022-103/-107-F1,-1F2,-F3 (Single and multiple weld repairs in plate and stiffener butt joints with and without flapper peening): These panels were repaired in the deck plate butt, two stiffener butts and two stiffener fillets. Repairs on one side of each specimen were flapper peened while the repairs on the other side were left in the as-welded condition. A detailed description of these repairs is given in Section 5.2.1.2.

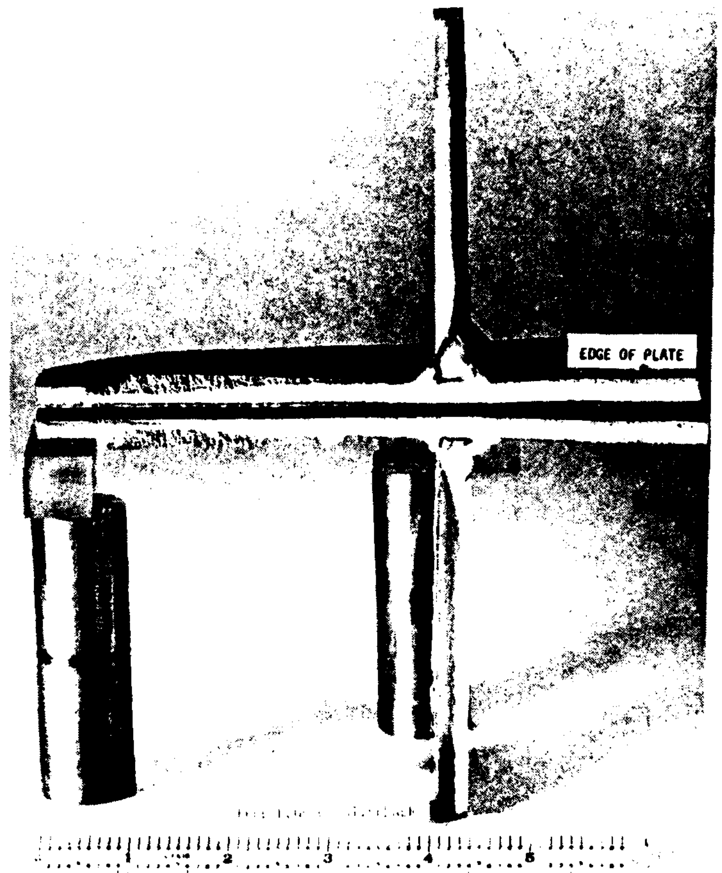
Fatigue failures were apparently all repair related on the unpeened side with crack origins at steep repair weld toe angles or an an abrupt end of a repaird fillet weld reinforcement.

No failures occured at repairs that were flapper peen processed. All of these repair weld reinforcements required fairing to ensure peening brush access. Consequently, the steep repair reinforcement toe angles were removed.

The lower fatigue strength of multiple repair compared to single repair panels, was attributed to a higher incidence of critical stress concentrations due to repairs on both weld surfaces.



(a) (790779-5) Specimen Overall View



(b) (800002-2) Fracture Surface Detail Showing Origins at Plate Butt Weld

Figure 5-30. Stiffened Panel Fatigue Test Specimen No. TT802022-11-F1 (Mismatched Butt Joints/Flapper Peened) After Failure.

(a) (790779-7) Specimen Overall View. (b) (790779-8) Stiffener Butt Joint Fracture Detail

Figure 5-31. Stiffened Panel Fatigue Test Specimen No. TT802022-11-F3 (Mismatched Butt Joints/Flapper Peened) After Failure.

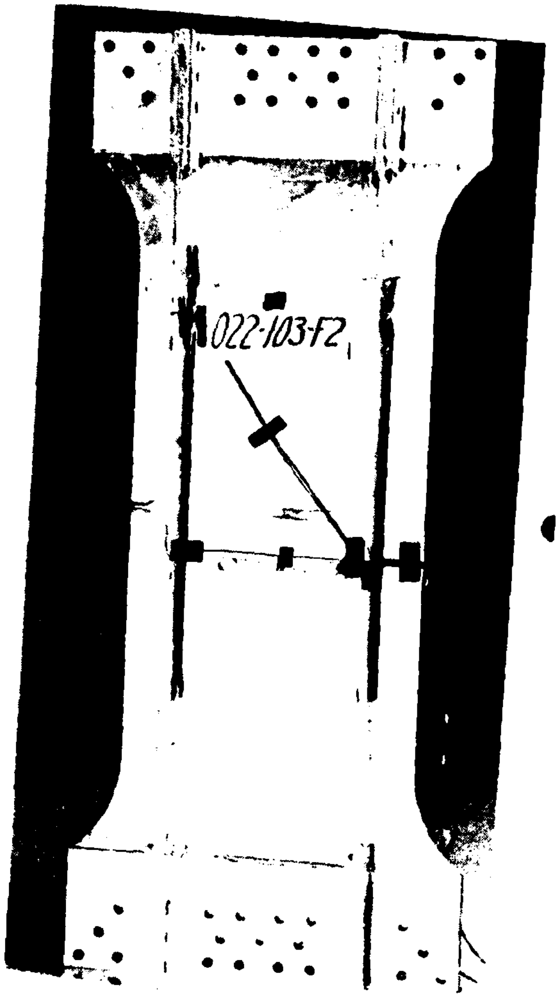
Photographs of the various fatigue failure modes exhibited by the repair weld specimens are presented in Figure 5-32 through 5-36. The failure of single repair specimen TT802022-103-F1 essentially duplicated the failure of the -F2 specimen shown in Figure 5-32. The single repair speciment -103-F2 and the multiple repair specimen -107-F1 both had evidence of lack of fushion in the fracture interface at or near the fatigue origin. Two lack of fushion areas were also apparent on the multiple repair panel -107-F3 which had the lowest strength of the three specimens.

e. Specimens TT802022-205-F1,-F2,-F3 (Doublers adhesively bonded over single weld repairs at mid plate and two stiffener butt joints): All three specimens failed in the stiffener butt welds without repair, signifying "run-out" conditions for this type panel. The failures obtained can be considered part of the baseline panel data group, and are of comparable strength levels despite evidence of weld lack of fushion in the fracture surfaces of the first two panels and weld porosite in the third panel. A steep weld reinforcement toe angle was also noted at the failure origin on the second panel.

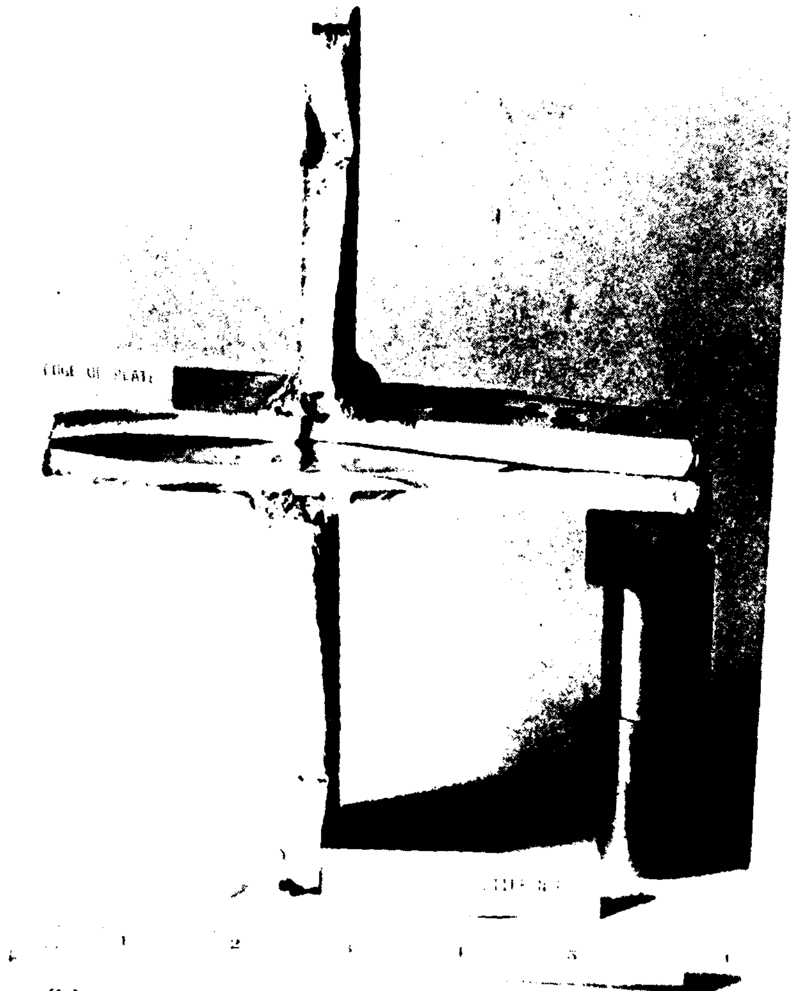
When considered as run-outs for the repaired specimen mode, these conservative strength levels fall between the multiple and single repaired panel levels and indicate the potential of greater strength than single repair specimens.

Failure modes for these panels are shown in Figures 5-37 and 5-38.

f. Specimens TT802022-203-F1,-F2,-F3 (Doublers riveted over single weld repairs at mid plate and two stiffener butt joints): Riveted doublers over single weld repairs did not improve repaired panel fatigue strength. The repaired/riveted areas were more fatigue critical than the normal stiffener butt welds on the opposite ends of the panels.

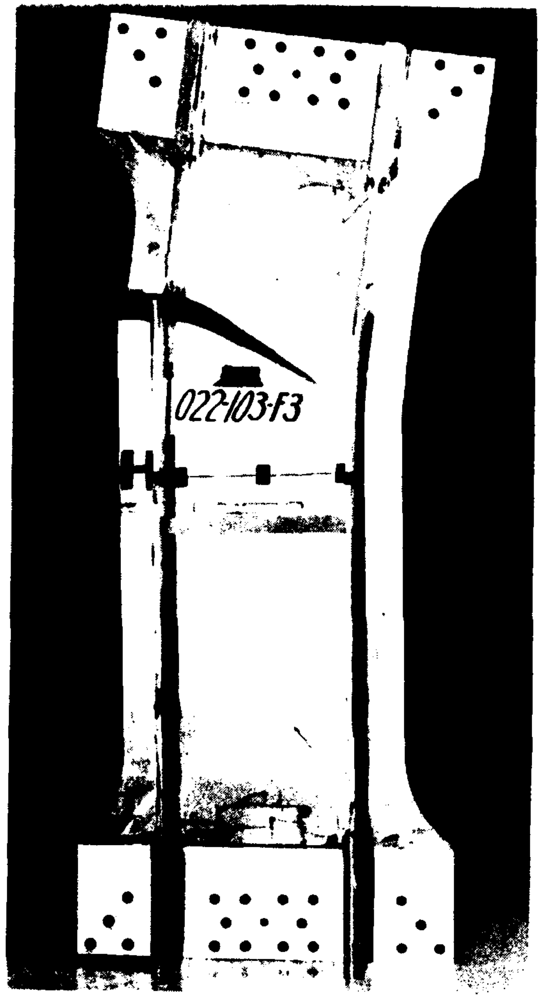


(a) (790859-8) Specimen Overall View



(b) (790974-8) Fracture Surface Detail
(Note lack of fusion at stiffener weld repair)

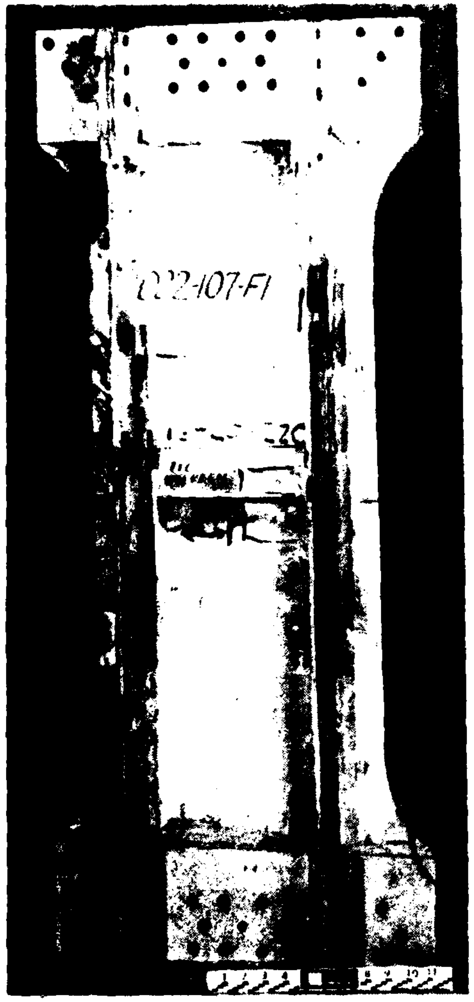
Figure 5-32. Stiffened Panel Fatigue Test Specimen No. TT802022-103-F2 (Single Weld Repairs) After Failure.



(a) (790859-3) Specimen Overall View

(b) (790859-16) Close-Up View of Fracture. (Origin in stiffener fillet weld)

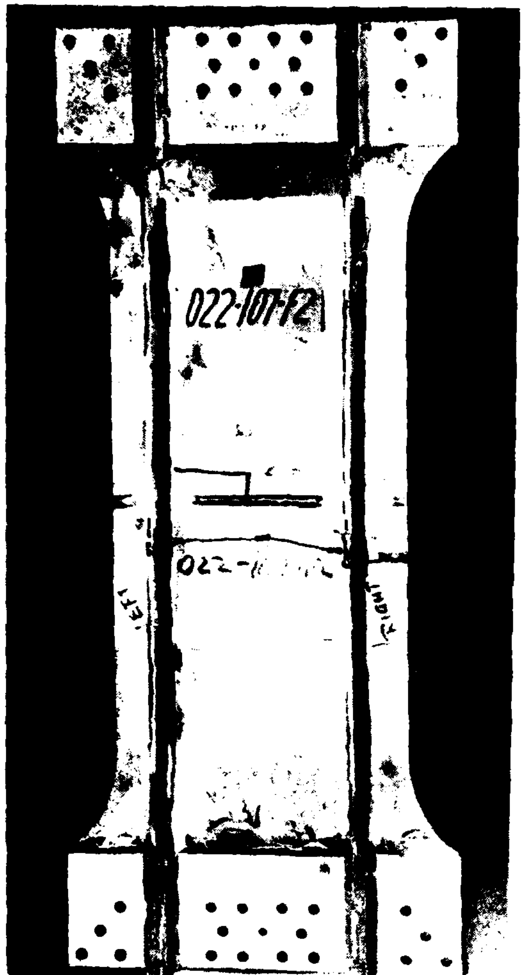
Figure 5-33. Stiffened Panel Fatigue Test Specimen No. TT802022-103-F3 (Single Weld Repairs) After Failure



(a) (790779-2) Specimen Overall View

(b) (790779-1) Stiffener Repaired Weld Fracture Detail

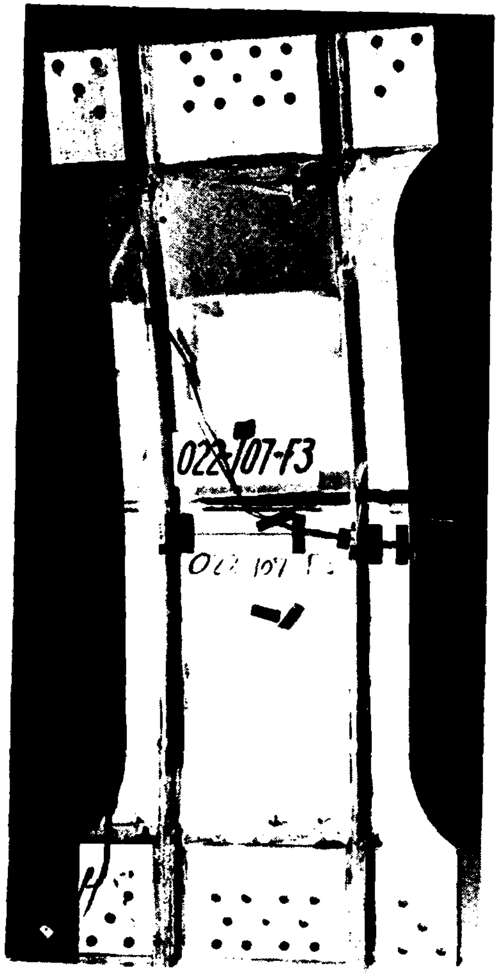
Figure 5-34. Stiffened Panel Fatigue Test Specimen No. TT802022-107-F1 (Multiple Weld Repairs) After Failure



(a) (790859-7) Specimen Overall View

(b) (790859-11) Stiffener Repaired Weld Fracture Detail

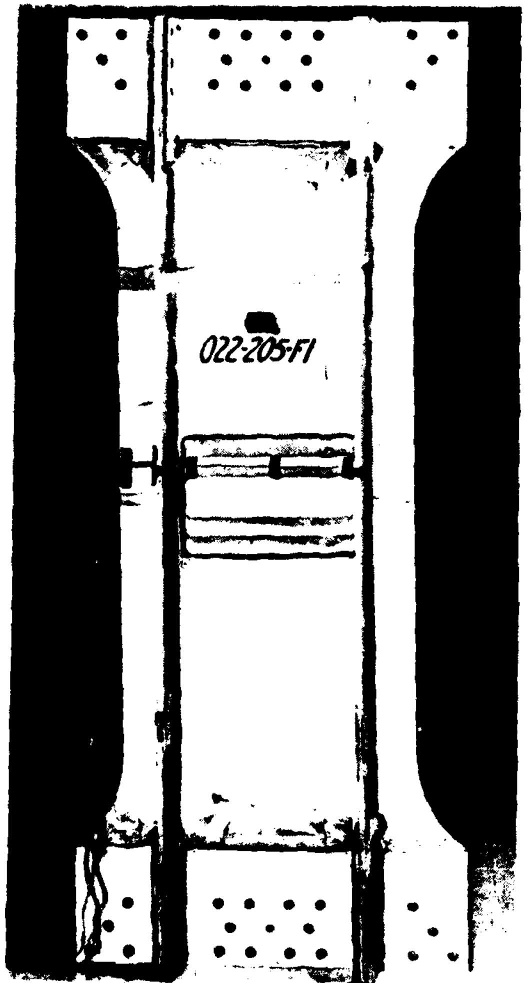
Figure 5-35. Stiffened Panel Fatigue Test Specimen No. TT802022-107-F2 (Multiple Weld Repairs) After Failure



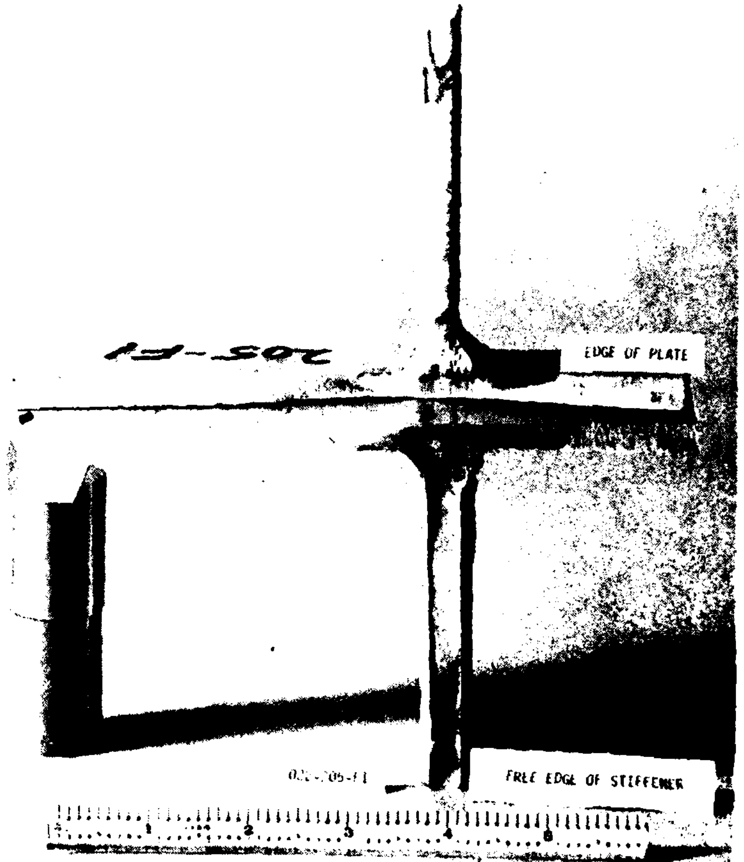
(a) (790859-4) Specimen Overall View

(b) (790859-17) Close-Up View of Repaired Plate Butt Weld Failure Origin

Figure 5-36. Stiffened Panel Fatigue Test Specimen No. TT802022-107-F3 (Multiple Weld Repairs) After Failure

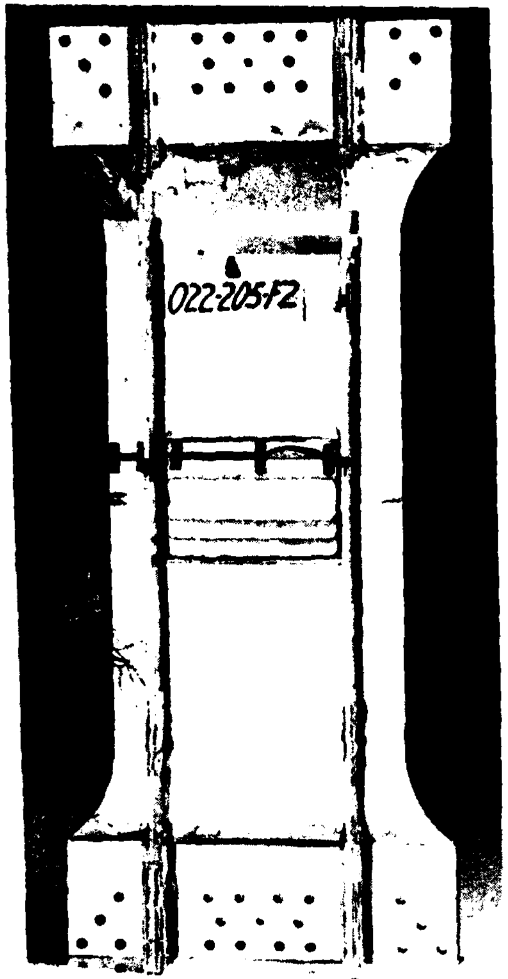


(a) (790859-2) Specimen Overall View

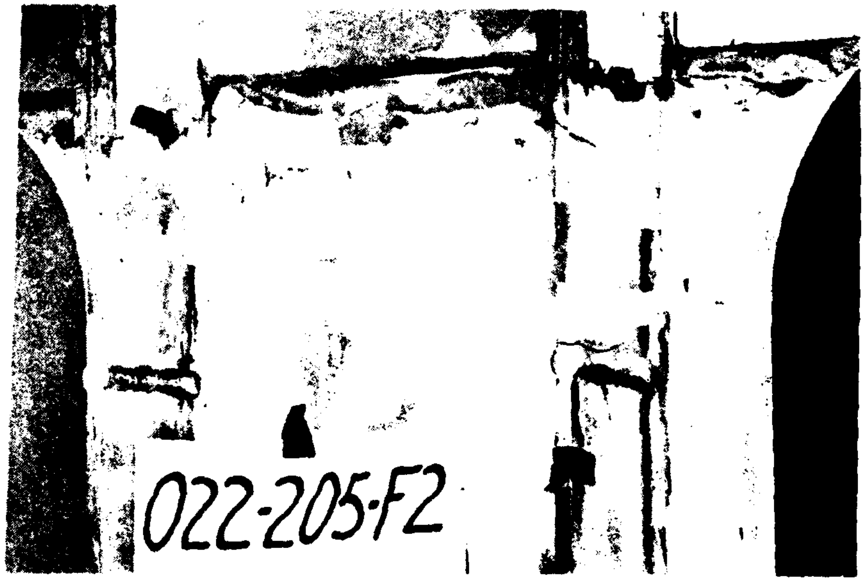


(b) (790974-9) Fracture Surfaces Detail. (Failure origin at stiffener butt weld with no repairs)

Figure 5-37. Stiffened Panel Fatigue Test Specimen No. TT802022-205-F1 (Bonded Doublers Over Weld Repairs) After Failure



(a) (790859-9) Specimen Overall View



(b) (790859-12) Detail of Failure (in stiffener butt weld without repairs)

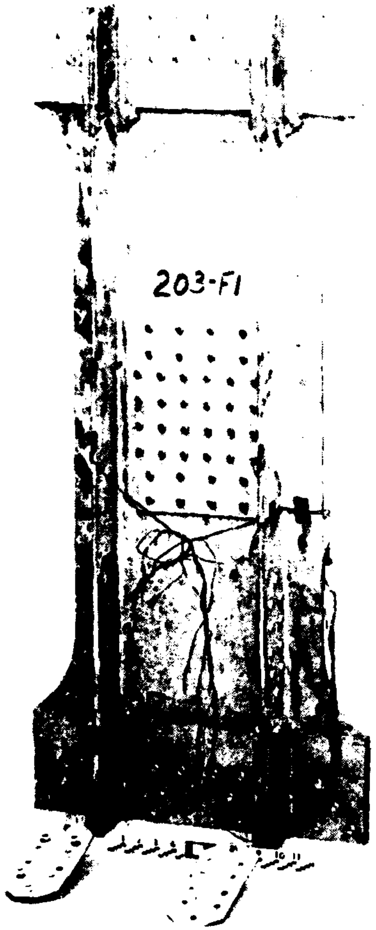
Figure 5-38. Stiffened Panel Fatigue Test Specimen No. TT802022-205-F2 (Bonded Doublers Over Weld Repairs) After Failure.

Two of the specimens failed through the stiffener rivet holes and the third failure occurred through a stiffener butt repair containing lack of fushion. Photographs of these failures are provided in Figure 5-39 and 5-40. Failure of the -203-F2 specimen essentially duplicated the failure shown in Figure 5-33 for the -203-F1 specimen.

g. Specimens TTB02022-201-F1,-F2,-F3 (Doublers riveted over unwelded stiffener butt joints): Stiffener butts joined by riveted doublers had a higher minimum fatigue strength compared to welded stiffener butt joints. The maximum achieved strength was equivalent to that for the welded butt baseline specimens but the scatter band was maller for the riveted joint specimen group.

   Two specimens (-F1 and -F2) failed through the stiffener rivet holes, and failure of the third initiated in a stiffener fillet weld near a stiffener butt. Photographs of these failures are shown in Figures 5-41 and 5-42. Failure of the -201-F2 specimen essentially duplicated that shown in Figure 5-41 for the -201-F1 specimen.

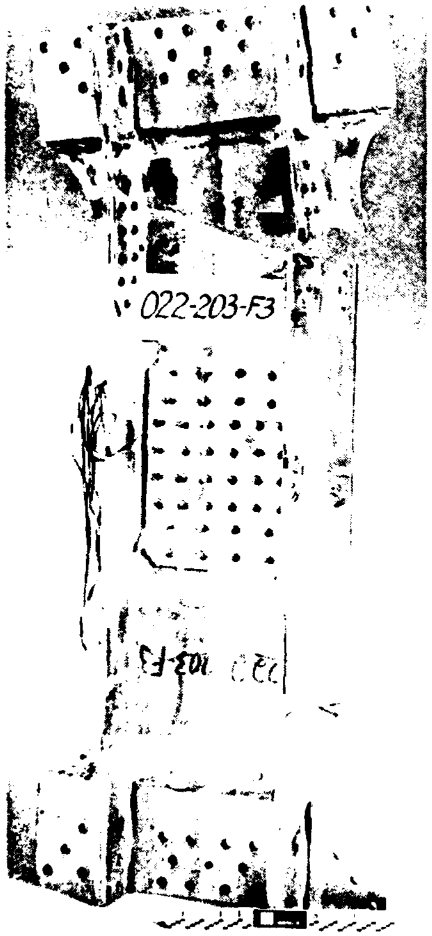
In summary, the majority of stiffened panel fatigue test failures occurred at the toes of butt weld reinforcements or through reinforcement doubler rivet holes. Instances were also encountered where the failures were attributed to weld abnormalities such as re-entrant angles or lack of fusion, examples of which are shown in Figure 5-43.



(a) (790518-10) Specimen Overall View

(b) (790518-3) Detail View of Failure (Origin at rivet hole)

Figure 5-39. Stiffened Panel Fatigue Test Specimen No. TT802022-203-F1 (Riveted Doublers Over Weld Repairs) After Failure.

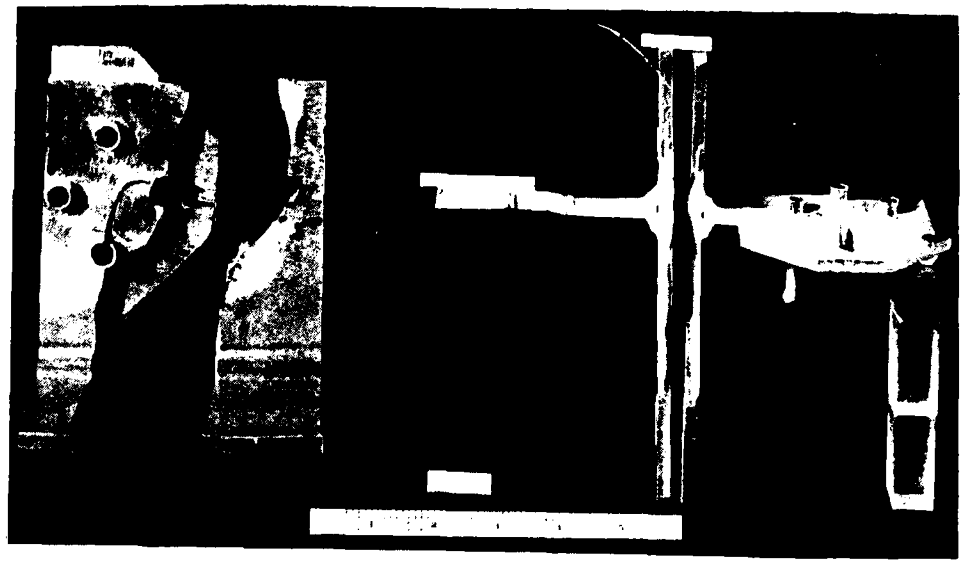


(a) (790779-18) Specimen Overall View

(b) (790974-3) Detail View of Fracture Surfaces. (Note failure origin at weld repair lack of fusion area.)

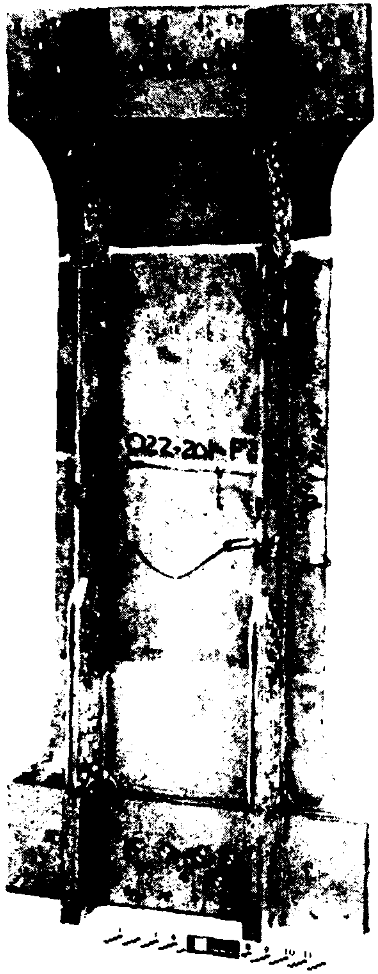
Figure 5-40. Stiffened Panel Fatigue Test Specimen No. TT802022-203-F3 (Riveted Doublers Over Weld Repairs) After Failure

(a) (790779-11) Specimen Overall View

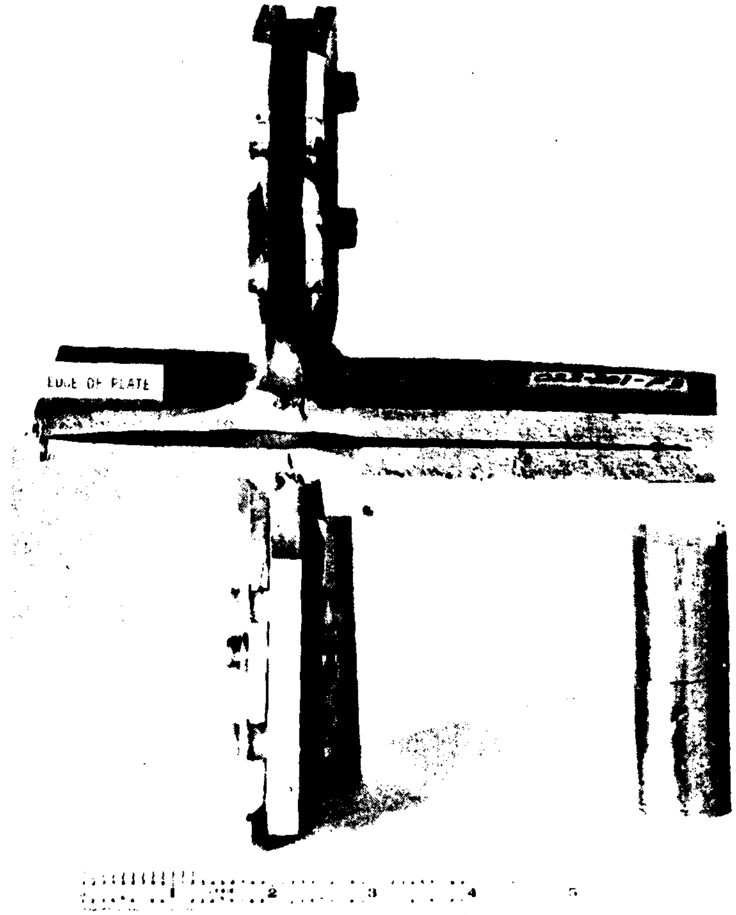


(b) (800019-1) Composite Detail Views of Fracture Area

Figure 5-41. Stiffened Panel Fatigue Test Specimen No. TT802022-201-F1 (Riveted Stiffener Butt Joints) After Failure

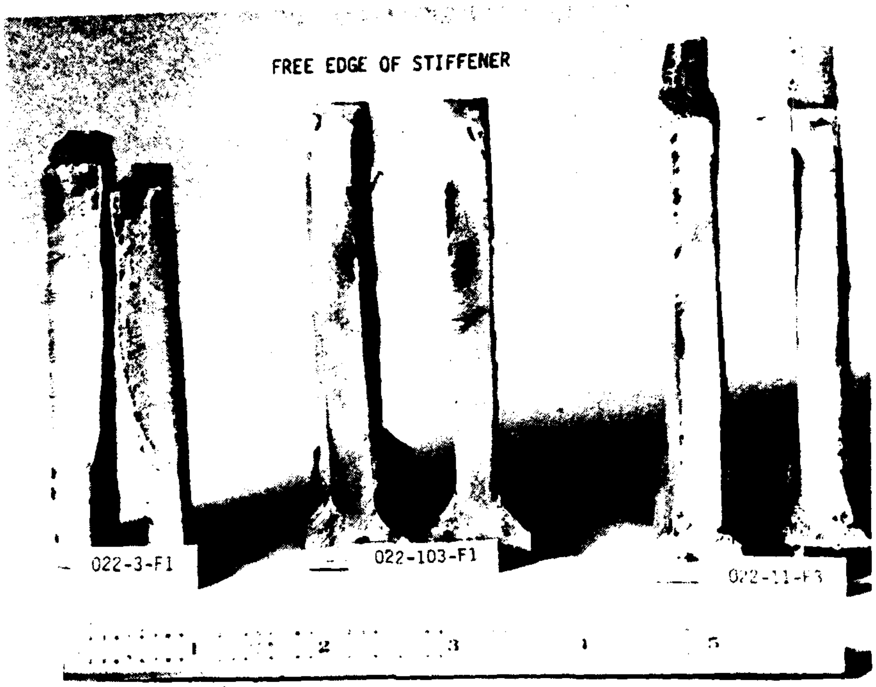


(a) (790518-11) Specimen Overall View

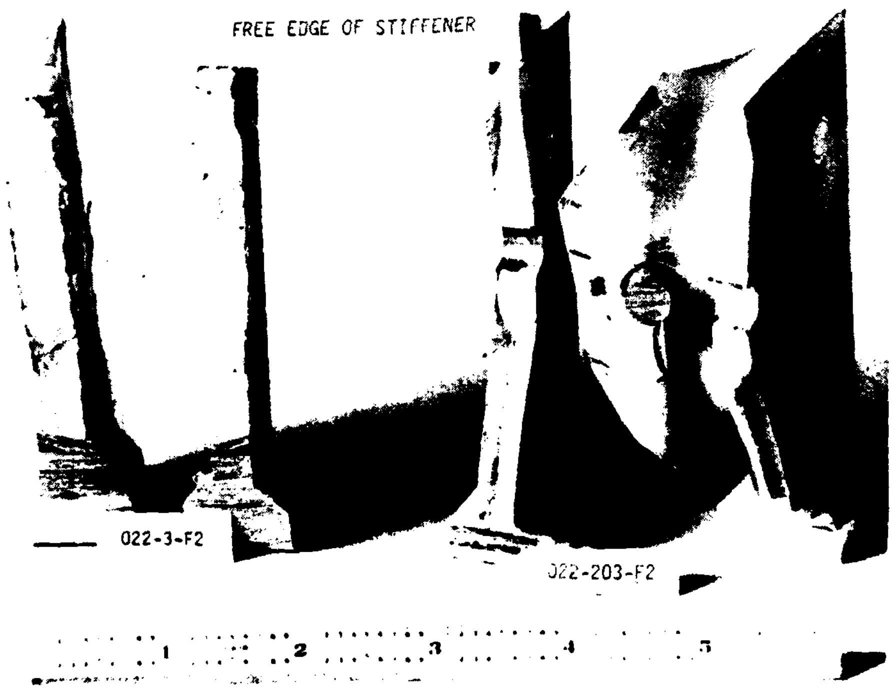


(a) (800002-1) Detail View of Fracture Surfaces at Failure Origin

Figure 5-42. Stiffened Panel Fatigue Test Specimen No. TT802022-201-F3 (Riveted Stiffener Butt Joints) After Failure.



(a) (790974-2)



(b) (790974-1)

Figure 5-43. Stiffener Fatigue Fracture Surfaces Removed from Selected Stiffened Panel Test Specimens.

5.7.3 STATIC COMPRESSION TESTS

5.7.3.1 General -- Twenty-six panel specimens of thirteen configuration variations were tested under axial compression static loading; and the results are presented in Table 5-7. All detail test data recorded from these tests is provided in Appendix D. The data provided for each specimen includes the autographic plot of applied load versus total compressive deformation and completion tabulations of the recorded strain gage and displacement transducer readings at all loading increments.

Local buckling of the flatbar stiffeners was the predominant failure mode; occurring during the stiffened panel axial compression tests; 19 specimens failed in this manner. Four specimens failed by stiffener bowing and the remaining three failed by plate buckling. A composite plot of compression load versus axial deformation for all of the stiffened panel test specimens is presented in Figure 5-44. Comparison of the various envelopes and curves shown in Figure 5-44 reveals a significant variation in the panel buckling characteristics and post-buckling load-carrying capabilities.

The buckling loads presented in Table 5-7 were determined from plots of lateral displacements versus test loads using the "top-of-the-knee" method described in Reference 16. Displacements and applied loads were normalized to the specimen material thickness and critical load, respectively. The critical load was calculated as follows using the method presented in Reference 17:

Stiffener buckling stress $f_{bs} = 0.383E \left(\frac{t_s}{b_s}\right)^2$

Plate buckling stress $f_{bp} = 3.62E \left(\frac{t_p}{b_p}\right)^2$ and

Critical panel buckling load $P_{cv} = A(\text{lesser of } f_{bs} \text{ and } f_{b_p})$

where E = Young's modulus

t = element thickness

b = element width

Table 5-7. Stiffened Panel Compression Test Results.

Specimen No. TT802023-	Specimen Type (1)	Min. Cross Section Area (in^2)	Failure Load (kips)	Buckling Load (kips)		Stress (ksi)		Failure Mode
				Test	Predicted (2)	At Failure	At Buckling	
3-1	A	6.40	157.0	148.6	132.6	24.5	23.2	Stif. buckle near center
3-2	A	6.42	158.3	149.8	132.6	24.6	23.3	Stif. buckle near center
7-1	A°	6.44	147.0	141.3	134.6	22.8	21.9	Stif. buckle near center
7-2	A°	6.42	160.0	149.5	133.5	24.9	23.3	Stif. buckle near center
101-1	B_1	5.39	115.0	110.0	85.9	21.4	20.4	Plate buckle near center
101-2	B_1	5.28	112.5	109.4	81.1	21.3	20.7	Stif. buckle near center
201-1	B_2	9.49	222.3	217.3	187.4	23.4	22.9	Stif. buckle near end
201-2	B_2	9.55	219.0	215.7	194.3	22.9	22.6	Stif. buckle near end
103-1	C_1	5.37	100.5	90.4	80.7	18.7	16.9	Stif. buckle near end
103-2	C_1	5.34	96.5	86.8	80.4	18.1	16.2	Stif. bowed
203-1	C_2	9.53	211.0	199.8	195.9	22.1	21.0	Stif. bowed
203-2	C_2	9.51	207.5	201.5	195.6	21.8	21.2	Stif. buckle at center
105-1	D_1	5.31	94.5	88.6	79.1	17.8	16.7	Stif. bowed
105-2	D_1	5.36	99.0	93.6	81.4	18.5	17.5	Stif. buckle near center
205-1	D_2	9.58	227.0	221.2	195.7	23.7	23.1	Stif. buckles near center and near end
205-2	D_2	9.61	232.0	221.3	195.8	24.2	23.0	Stif. buckle near center
107-1	E_1	5.41	91.0	88.0	84.7	16.8	16.3	Stif. buckle near center
107-2	E_1	5.42	94.8	89.1	85.7	17.5	16.4	Stif. buckle near center
207-1	E_2	9.63	228.8	220.4	196.7	23.8	22.9	Stif. bowed
207-2	E_2	9.58	217.0	210.3	191.2	22.6	22.0	Stif. buckle near center
111-1	F_1	5.33	101.0	99.3	79.4	18.9	18.6	Stif. buckle near end
111-2	F_1	5.34	100.6	99.4	79.5	18.8	18.4	Stif. buckle near end
211-1	F_2	9.54	246.5	239.7	193.3	25.8	25.1	Stif. buckle near end
211-2	F_2	9.49	236.5	236.7	194.1	24.9	24.9	Stif. buckle near end
11-1	G	6.67	175.0	170.3	112.1	26.2	25.5	Plate buckle near center
11-2	G	6.63	169.C	165.5	110.4	25.5	25.0	Plate buckle near center

Notes:

(1) Specimen Type Code:

A - Baseline panel haunched stiffeners - No Welds.

A°- Same as A except straightened after longitudinal bending until stiffeners buckled.

B - Mismatch at plate and stiffener butt weld joints.

C - Stiffener butt joints angularly misaligned stiffeners bowed laterally 1/4 inch.

D - Stiffeners bowed laterally 1/4 inch.

E - Stiffeners bowed laterally 3/8 inch.

F - Stiffeners bowed laterally 3/8 inch with chock between stiffeners.

G - Doublers riveted over unwelded stiffener butt joints.

Subscripts

1 - .200 plate with .250 stiffener
2 - .344 plate with .375 stiffener

(2) *Prediction based on minimum canculated buckling stress (see Paragraph 5.7.3).*

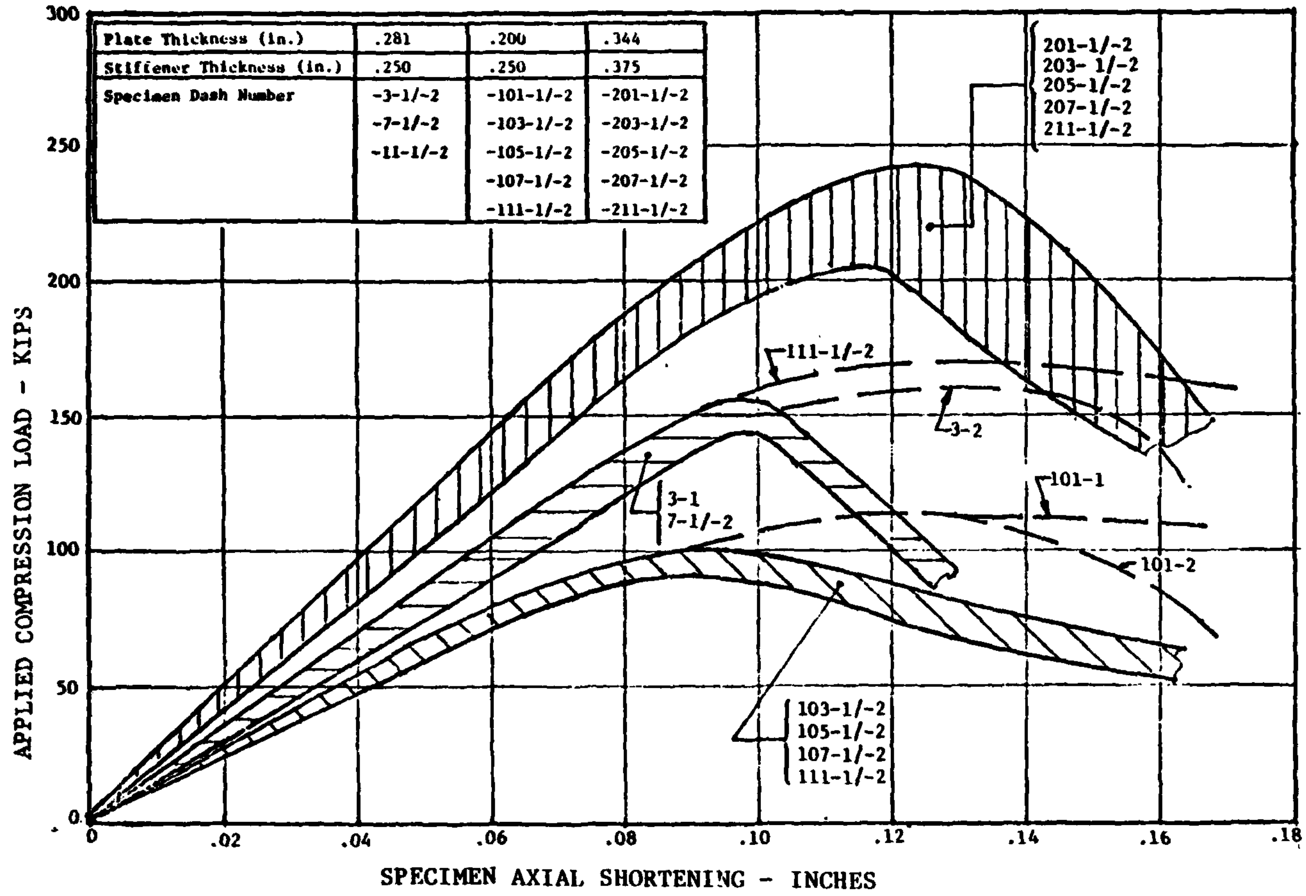


Figure 5-44. Stiffened Panel Compression Test Specimen Load-Deflection Curves and Envelopes.

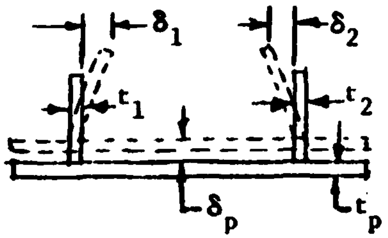
Figure 5-45 illustrates the use of the "top-of-the-knee" method for determining the panel strength at the onset of buckling.

Discussions of the results from the various panel configuration axial compression tests are contained in the following paragraphs. Each type of panel configuration and failure mode is illustrated by one (or more) photographs, measured strain-vs-nominal applied stress plots, and a graphical presentation of displacements for increments of nominal stress.

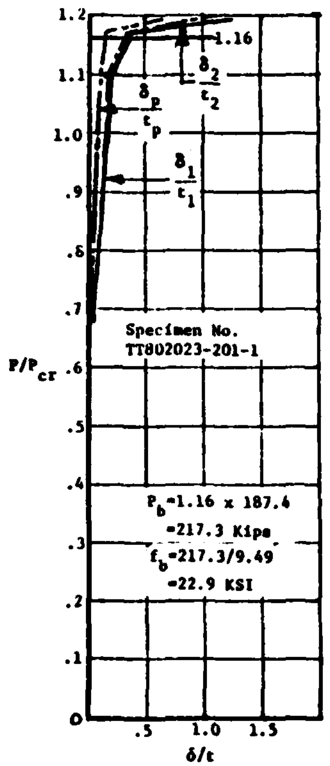
5.7.3.2 Baseline Panel Test Results -- Four baseline panels were tested; two panels in the as-fabricated condition (TT802023-3-1/-2) and two panels which were mechanically bowed and straightened before testing (TT802023-7-V-2). All four specimens failed by stiffener buckling near the panel mid-section, and three of the four specimens exhibited equivalent buckling and ultimate strengths. The other specimen, failed at a stress level only 6 percent below that of the other three specimens. One of each type of specimen is illustrated in Figure 5-46. Strain and displacement plots for these specimens are presented in Figures 5-47 through 5-50.

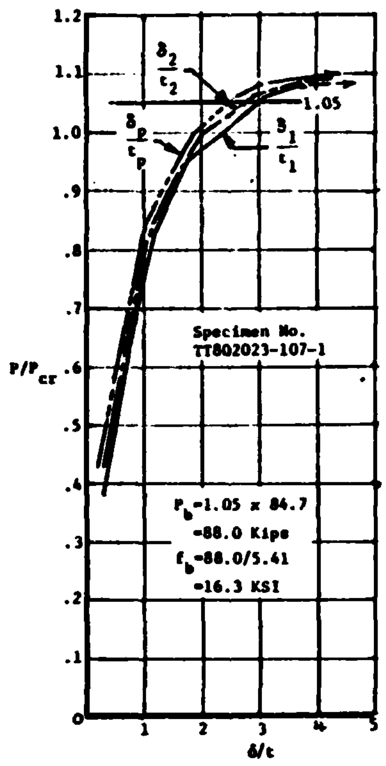
5.7.3.3 Test Results from Panels with Mismatch at Erection Butt Joints -- Four erection joint specimens with mismatched plate and stiffener butt welded joints were tested. Two specimens (TT802023-101 -1/-2) were made with .200 inch plate and 0.250 inch stiffeners representing "light" scantlings on the 3KSES structure, and the other two (TT802023-201-1/-2) were made with .344 inch plate and 0.375 stiffeners representing "average" panel scantlings. The thinner gage specimens failed in different modes near the specimen mid-sections. One failed by plate buckling and the other by stiffener buckling; however, these specimens exhibited equivalent strengths. Both of the thicker gage specimens failed by stiffener buckling near the stiffener erection joint, and these specimens also exhibited equivalent strengths. One of each failed specimen is illustrated in Figure 5-50; strain and deflection plots are shown in Figure 5-51 through 5-55.

P (KIPS)	δ_1 (IN)	δ_2 (IN)	δ_p (IN)	$\frac{P}{P_{cr}}$	$\frac{\delta_1}{t_1}$	$\frac{\delta_2}{t_2}$	$\frac{\delta_p}{t_p}$
Specimen No.-201-1. P_{cr} = 187.4 Kips: Area = 9.49 IN^2							
222.3	.431	.435	.205	1.19	1.15	1.18	.60
220	.120	.122	.036	1.17	.34	.33	.17
210	.082	.078	.031	1.12	.22	.21	.09
200	.063	.056	.026	1.07	.17	.15	.08
180	.042	.038	.017	.96	.10	.10	.05
Specimen No.-107-1. P_{cr} = 84.7 Kips: Area = 5.41 IN^2							
91	.958	.909	.614	1.08	3.74	3.57	3.01
90	.787	.722	.516	1.06	3.07	2.83	2.53
85	.562	.513	.376	1.00	2.20	2.01	1.84
80	.454	.415	.305	.95	1.77	1.63	1.50
70	.329	.300	.222	.83	1.23	1.18	1.09
60	.236	.211	.157	.71	.92	.83	.77
40	.119	.100	.077	.47	.46	.39	.38



P = Applied load
P_{cr} = Predicted buckling
P_b = Test buckling load

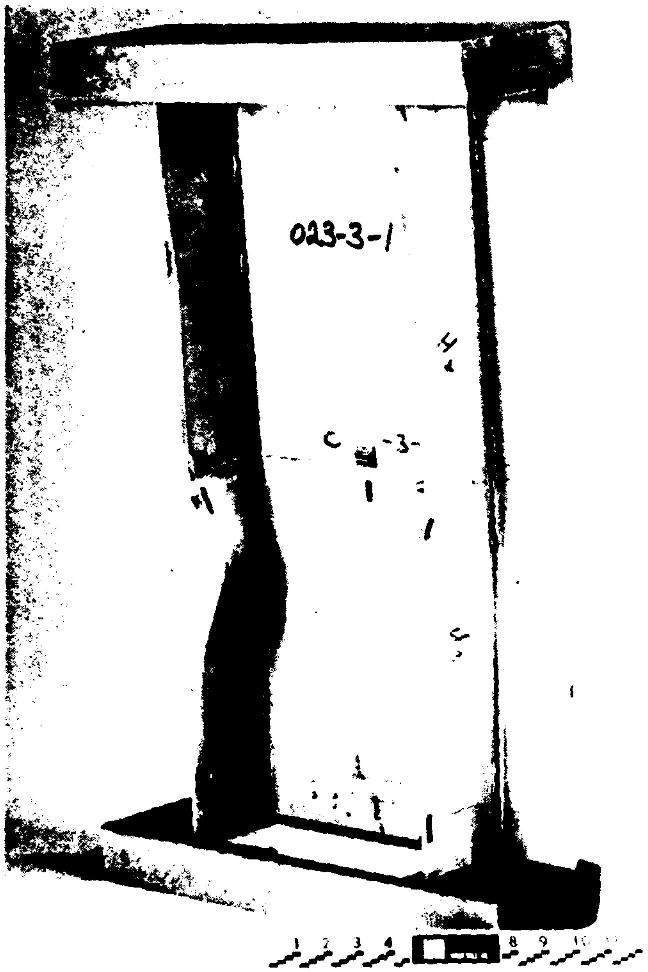




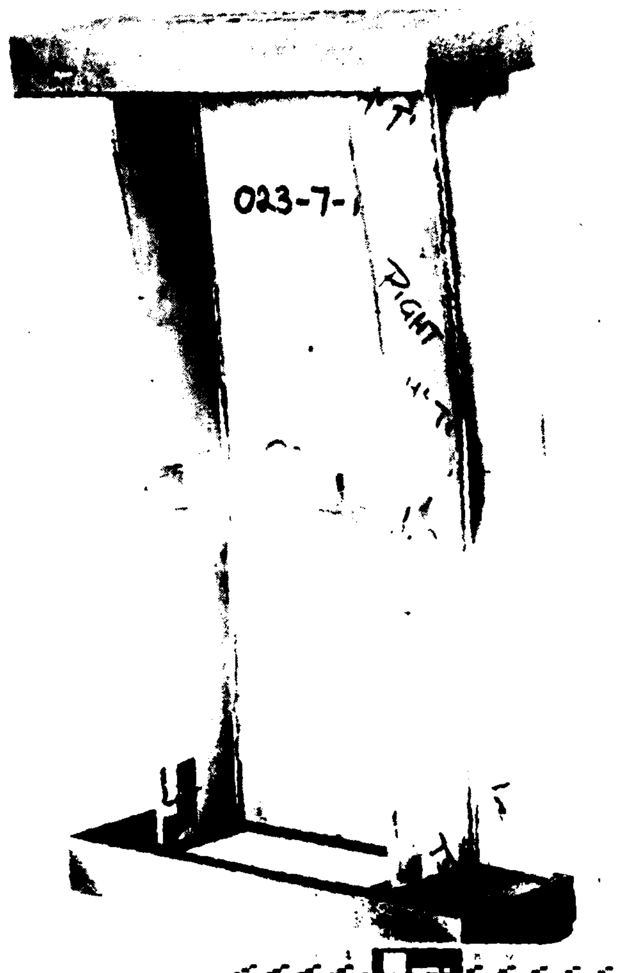
NOTES:

1. Measurement nomenclature as indicated on sketch; absolute values used in computations.
2. Stiffener deflections are at cross-section closest to buckle.
3. Plate deflections are at midspan.

Figure 5-45. Normalized Load-Deflection Plots for Buckling Load Determination.



(a) Specimen No. TT802023-3-1, Baseline



(b) Specimen No. TT802023-7-1, Longitudinally Bowed and Straightened.

Figure 5-46. Stiffened Panel Static Compression Test Specimens After Failure - Basic Configuration (Without Erection Joint Welds).

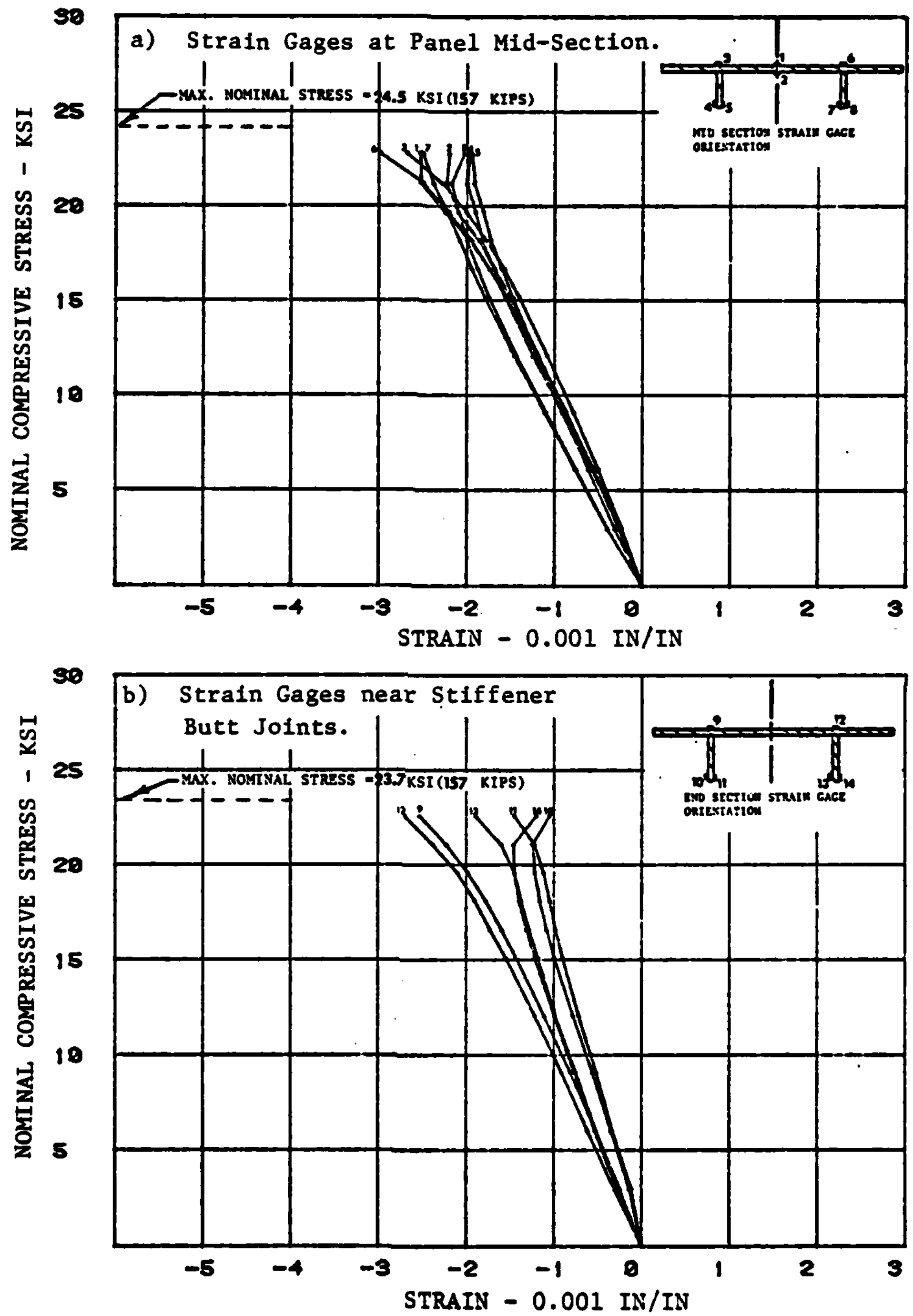


Figure 5-47. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-3-1 (Baseline Configuration with Haunched Stiffeners; No Butt Welds).

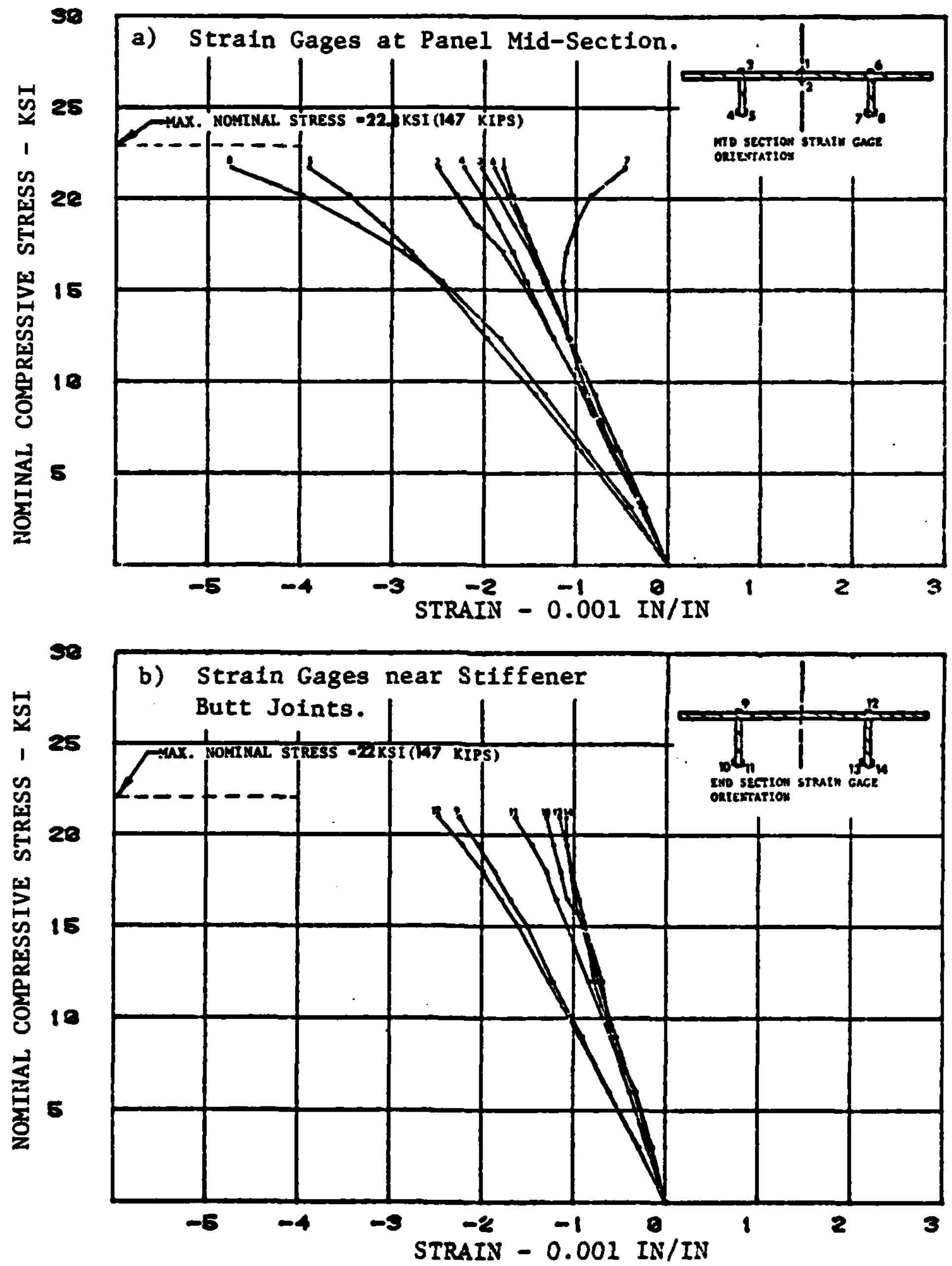


Figure 5-48. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-7-1. (Baseline Configuration with Haunched Stiffeners - Straightened After Deforming).

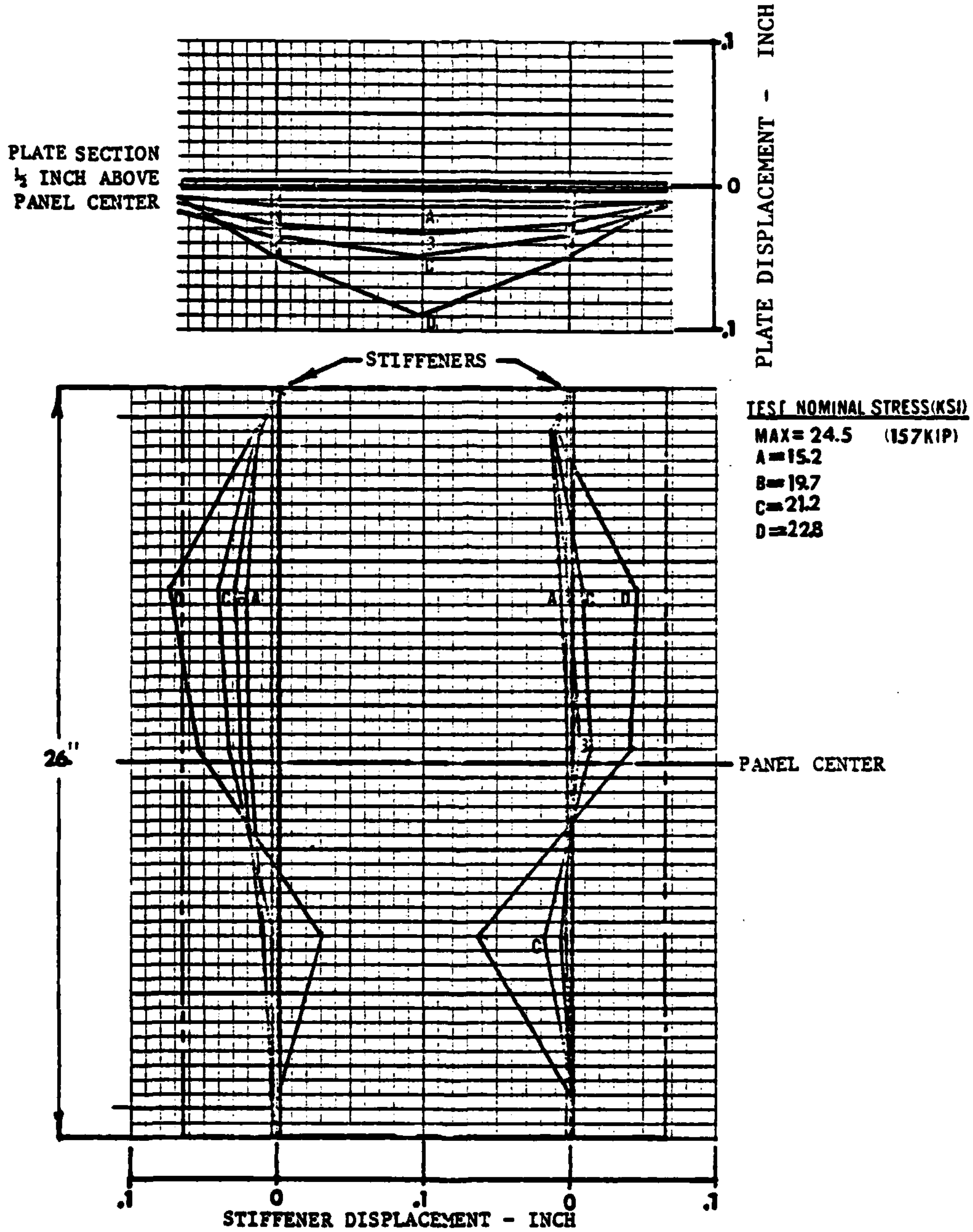


Figure 5-49. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-3-1.

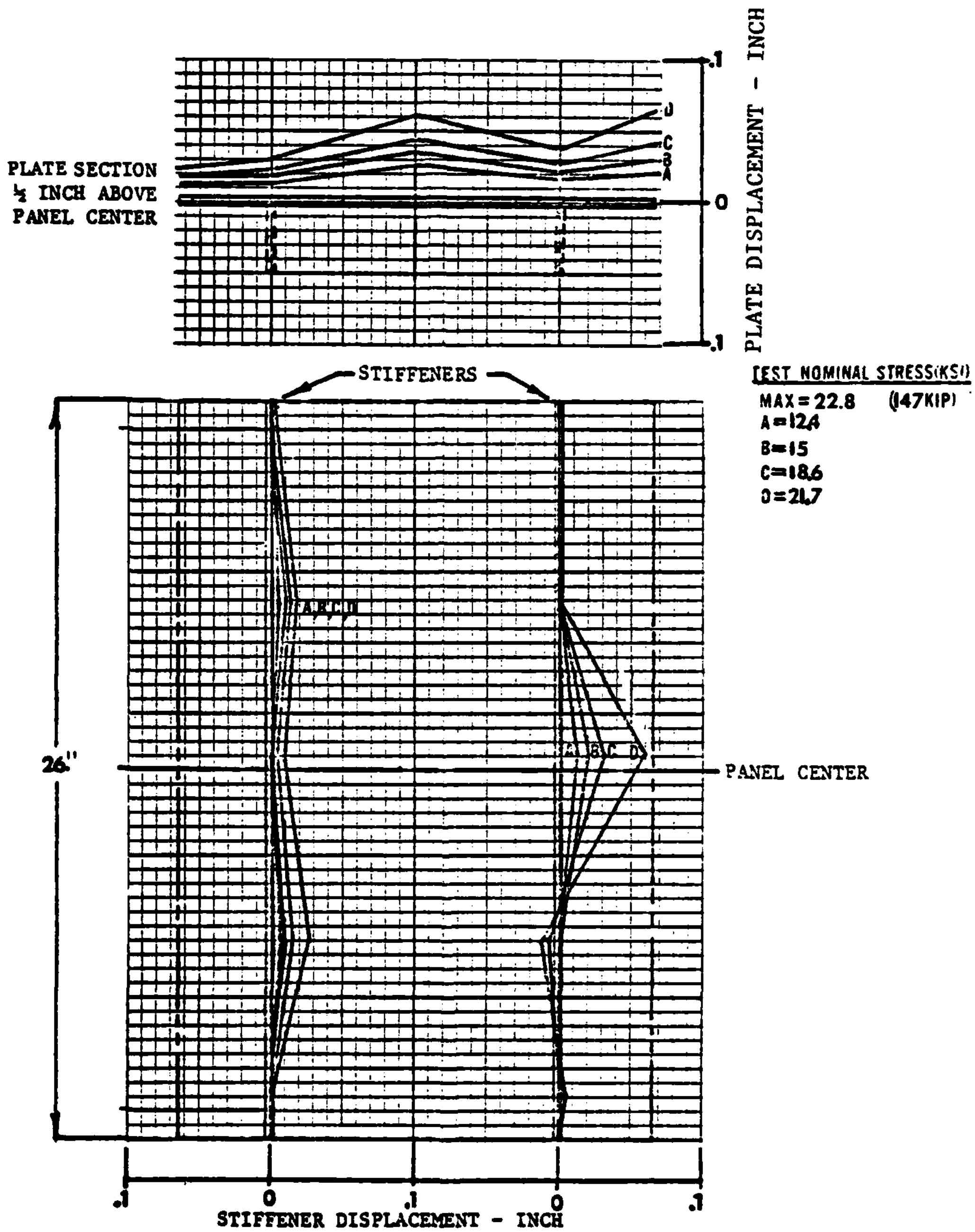
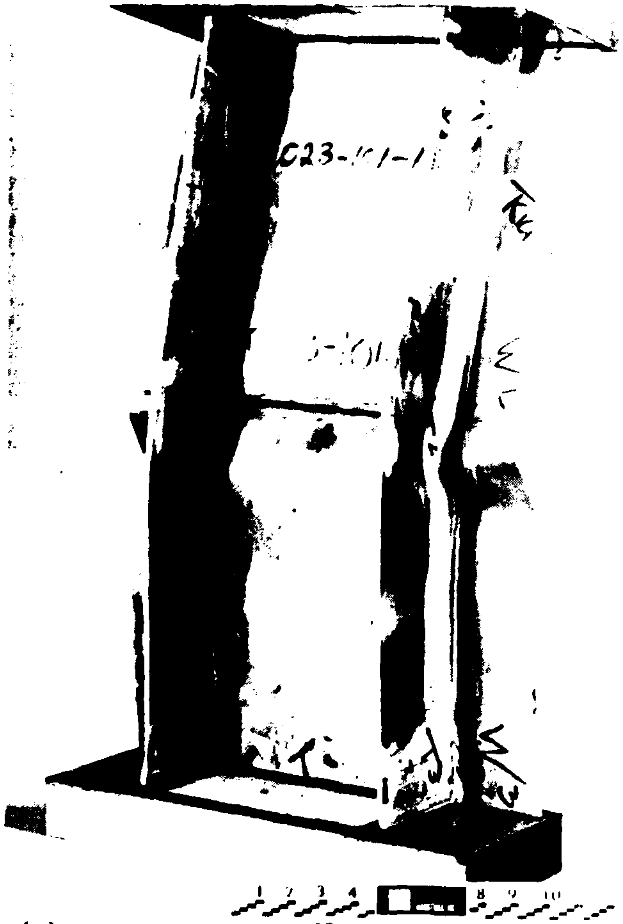
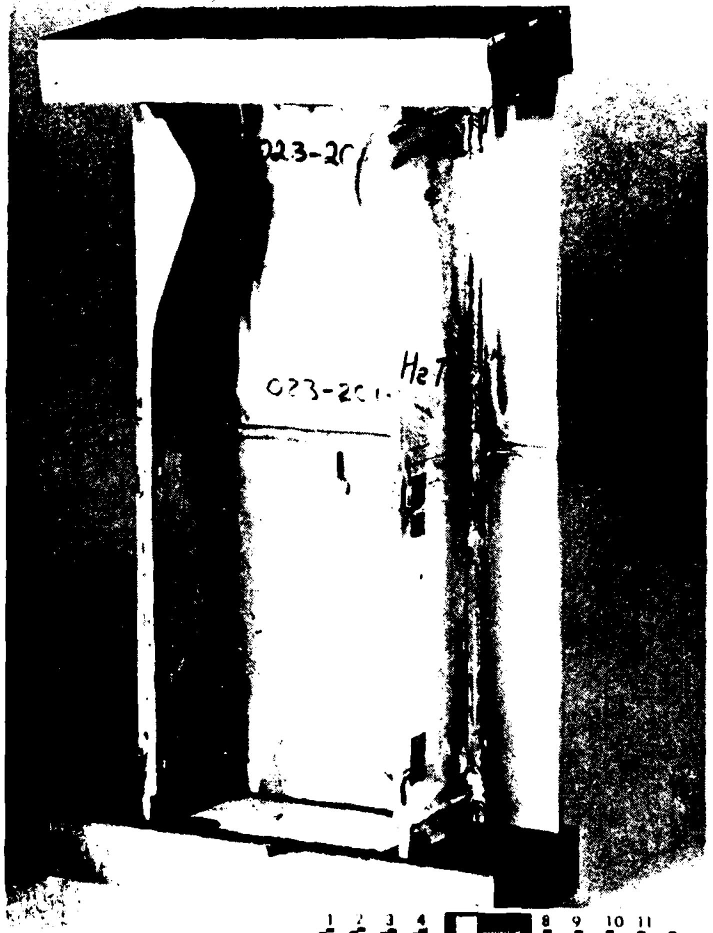


Figure 5-50. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-7-1.



(a) Specimen No. TT802023-101-1 (Thin Plate/ Stiffeners).



(b) Specimen No. TT802023-201-1 (Thick Plate/ Stiffeners).

Figure 5-51. Stiffened Panel Static Compression Test Specimens After Failure (Erection Joint Configuration with Offset Mismatch at Butt Welds)

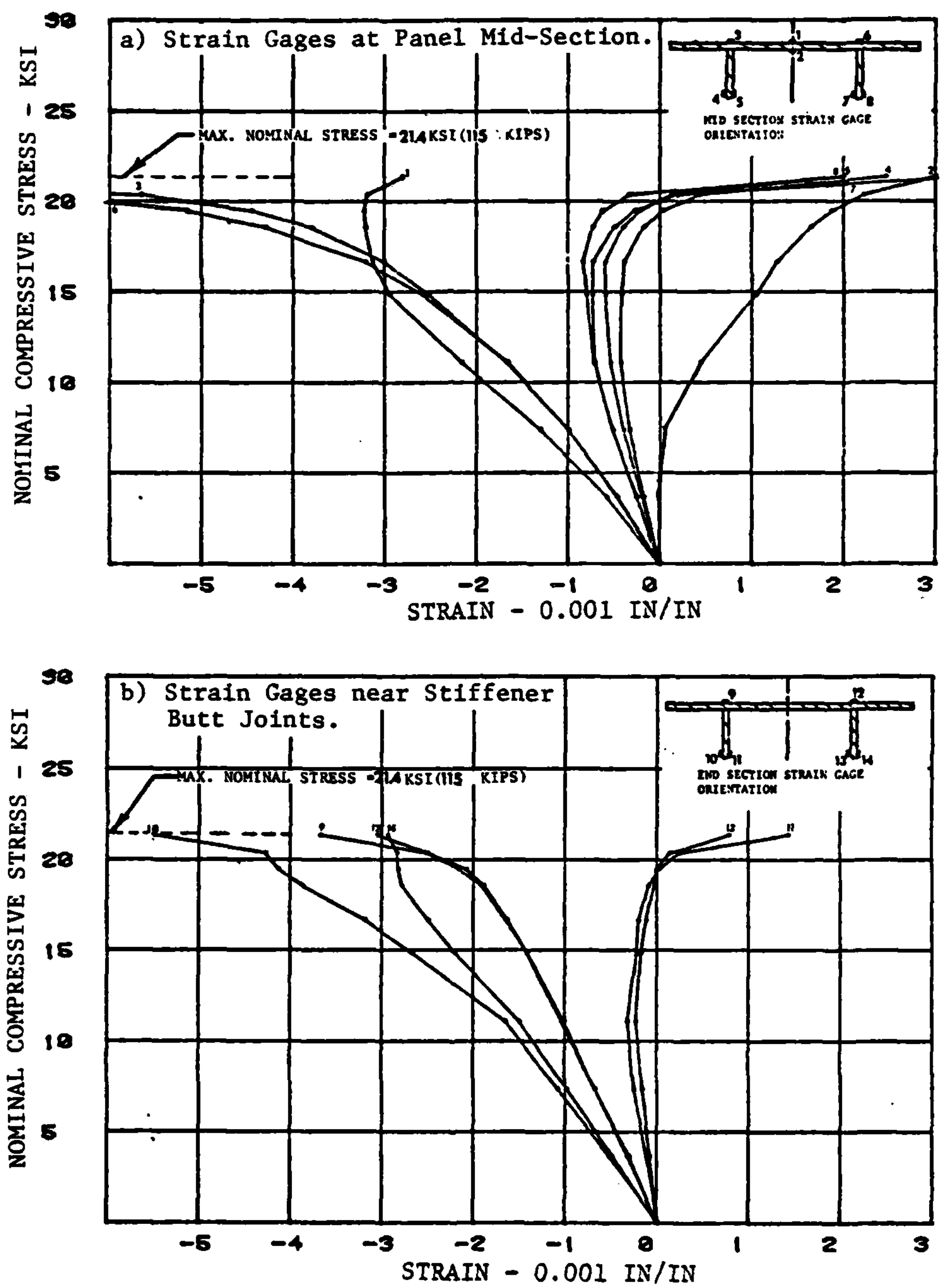
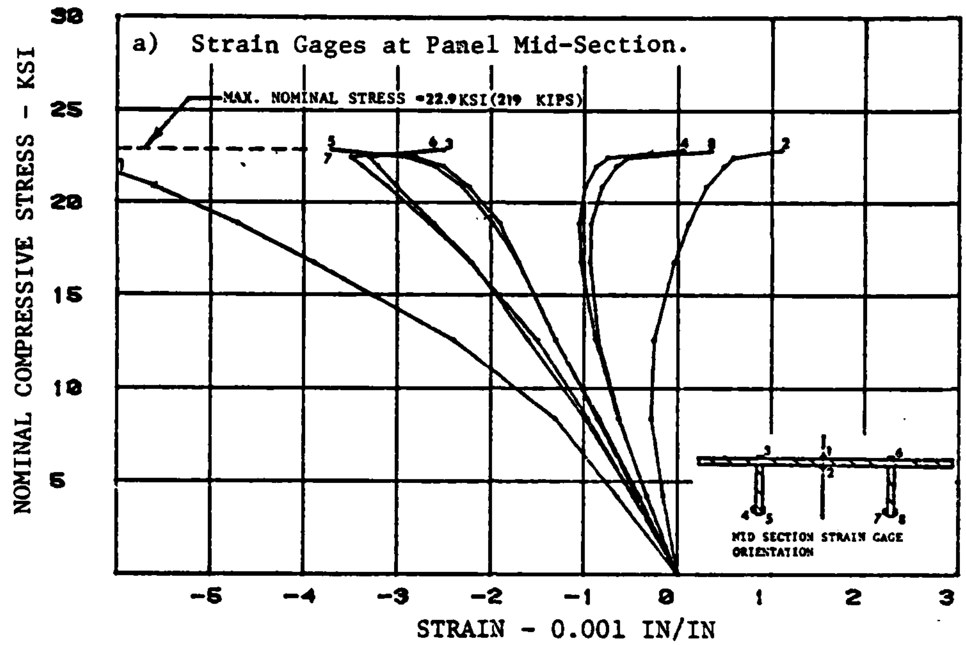


Figure 5-52. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-101-1 (Erection Joint "Light Scantling" Configuration with Mismatch in Plate and Stiffener Butt Weld Joints).



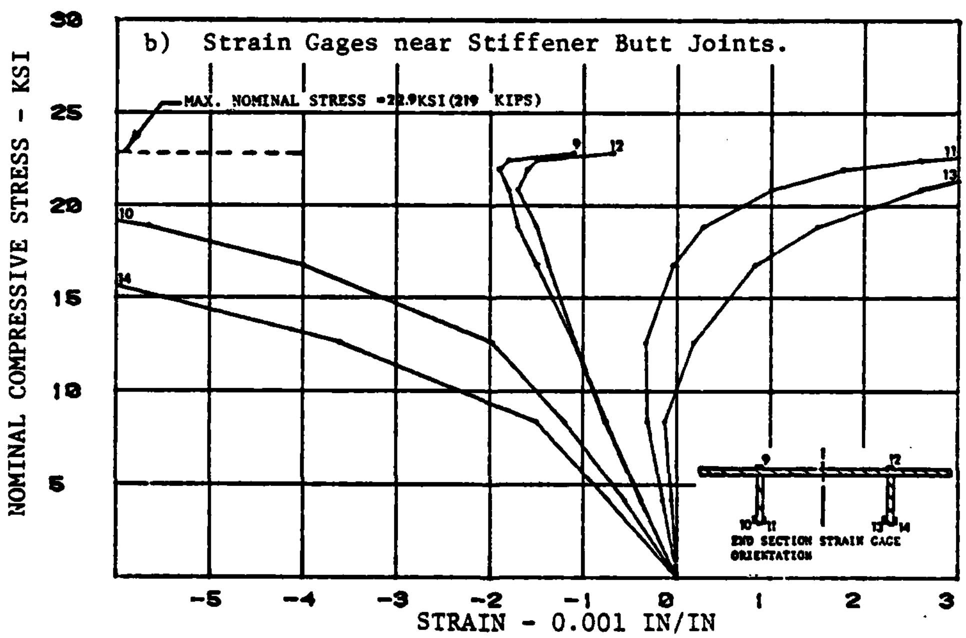


Figure 5-53. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-201-2 (Erection Joint "Average Scantling" Configuration with Mismatch in Plate and Stiffener Butt Weld Joints).

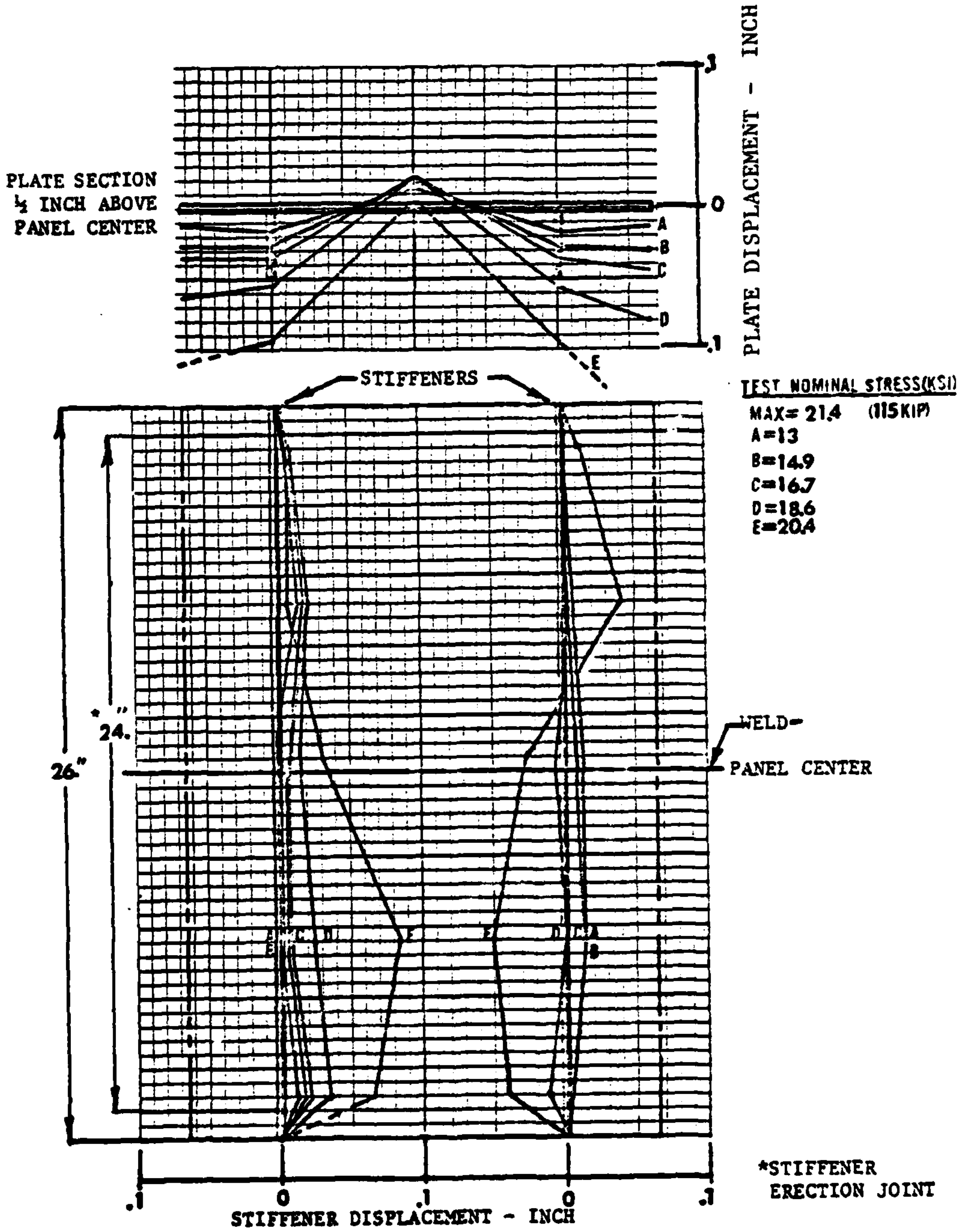


Figure 5-54. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-101-1.

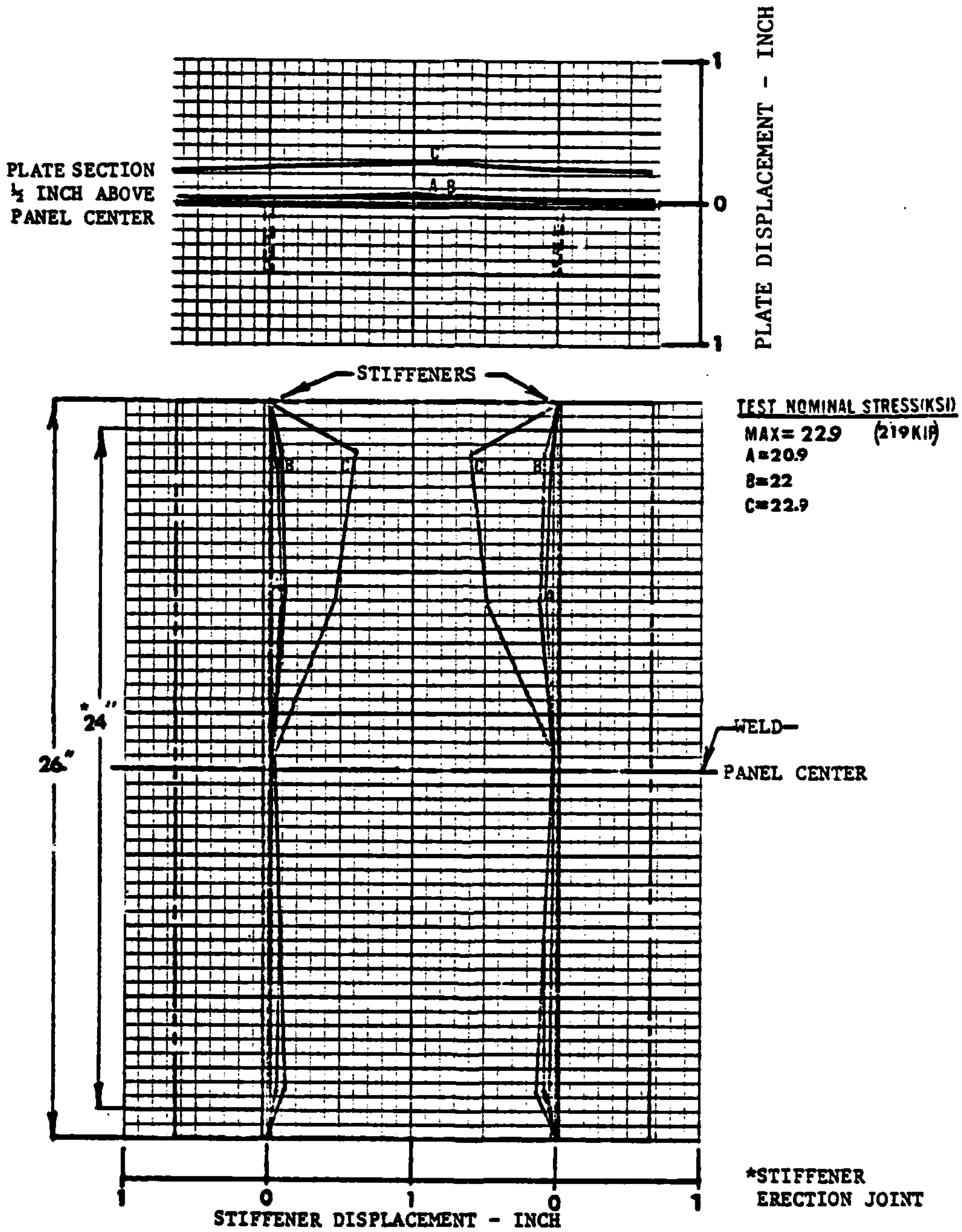
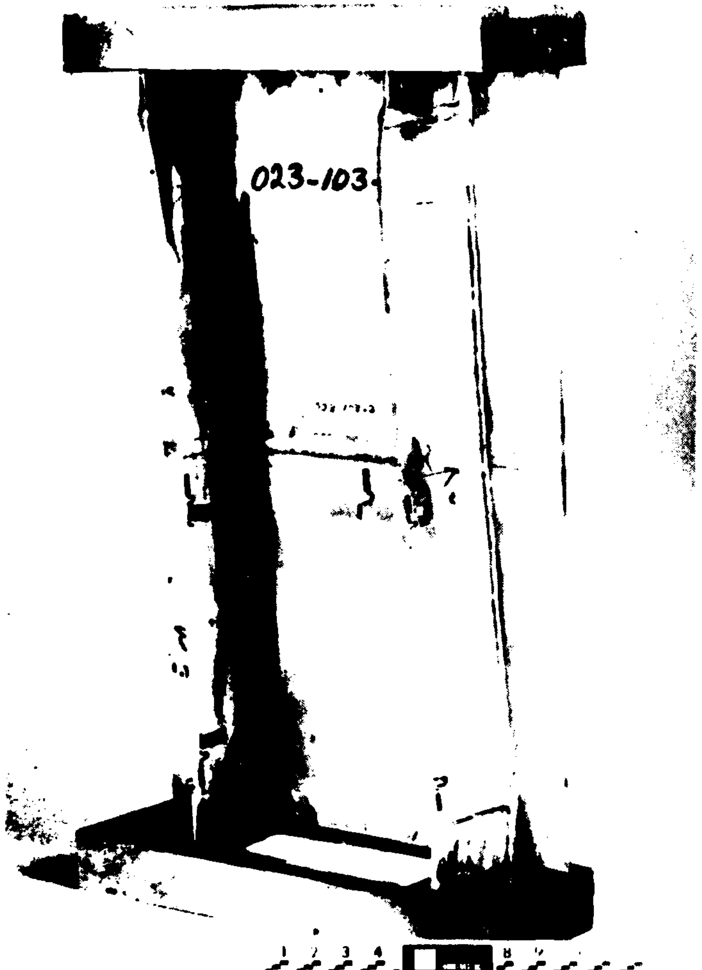


Figure 5-55. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-201-2.

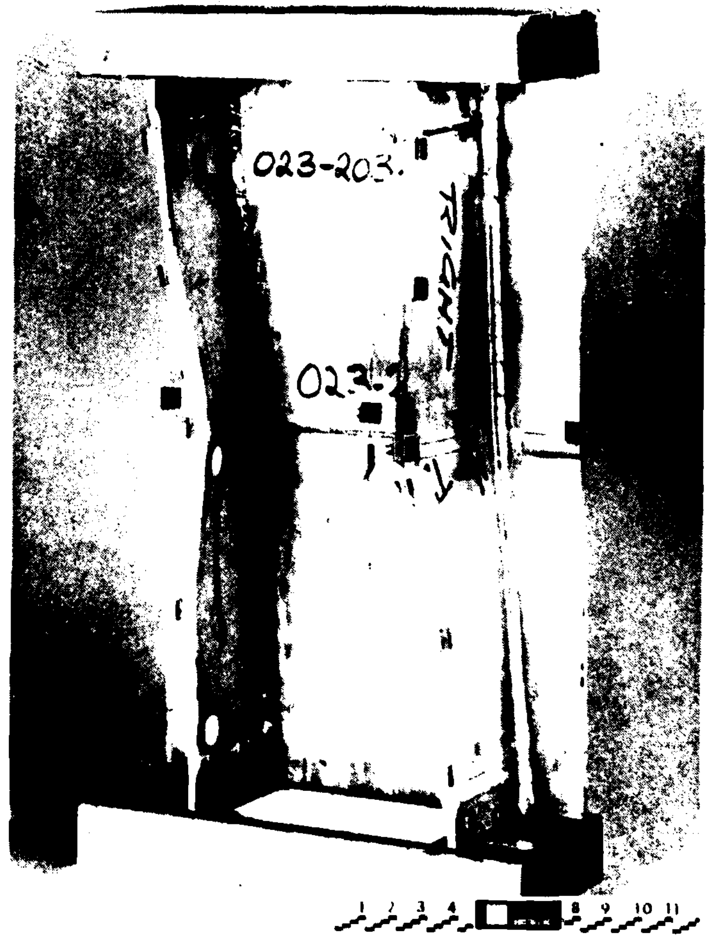
5.7.3.4 Test Results from Erection Joint Panels with Misaligned and Bowed Stiffeners -- These specimens were fabricated with the stiffeners misaligned 1 1/2 inches across the erection joint and with 1/4 inch inward bow in the stiffener free edge. Two specimens each of "light" (0.200/0.250) and "average" (0.344/0.375) plate/stiffener thickness combinations were tested. (Specimens TT802023-103-1/-2 & TT802023-203-1/-2, respectively). One specimen of each thickness combination failed by stiffener buckling, and one specimen of each thickness combination failed by stiffener bowing. Buckling and failure stresses were consistent within each specimen thickness combination. A typical specimen of each type is illustrated in Figure 5-56; strain and displacement plots are shown in Figures 5-57 through 5-60.

5.7.3.5 Test Results from Erection Joint Panels With Stiffeners Bowed 1/4 Inch -- Two specimens each of "light" (0.200/0.250) and "average" (0.344/0.375) plate/stiffener thickness combinations with the stiffener free edges bowed 1/4 inch inward were tested (TT802023-105-1/-2 and TT802023-205-1/-2, respectively). One of the "light" specimens failed in a bowed stiffener mode and the other three specimens failed by stiffener buckling; all but one of the stiffeners on the three letter specimens buckled near the panel mid-section. For the thin material configuration, the specimen which failed by stiffener bowing exhibited slightly lower (0.8 ksi) capability than the specimen which failed by stiffener buckling. The thicker material specimen strengths were essentially equal. A typical failed specimen of each material thickness configuration is illustrated in Figure 5-61 strain and displacement plots are shown in Figures 5-62 through 5-65.

5.7.3.6 Test Results from Erection Joint Panels with Stiffeners Bowed 3/8 Inch -- Two "light" (0.200/0.250) and two "average" (0.344/0.375) plate/stiffener thickness combination specimens with the stiffener free edges bowed 3/8 inch inward were tested (TT802023-107-1/-2 and TT802023-027-1/-2, respectively). Both "light" scantling specimens and one "average" scantling specimen failed by stiffener buckling near



(a) Specimen No. TT802023-103-2 (Thin Plate/ Stiffeners).



(b) Specimen No. TT802023-203-2 (Thick Plate/ Stiffeners).

Figure 5-56. Stiffened Panel Static Compression Test Specimens After Failure - Erection Joint Configuration with Misaligned and Bowed Stiffeners.

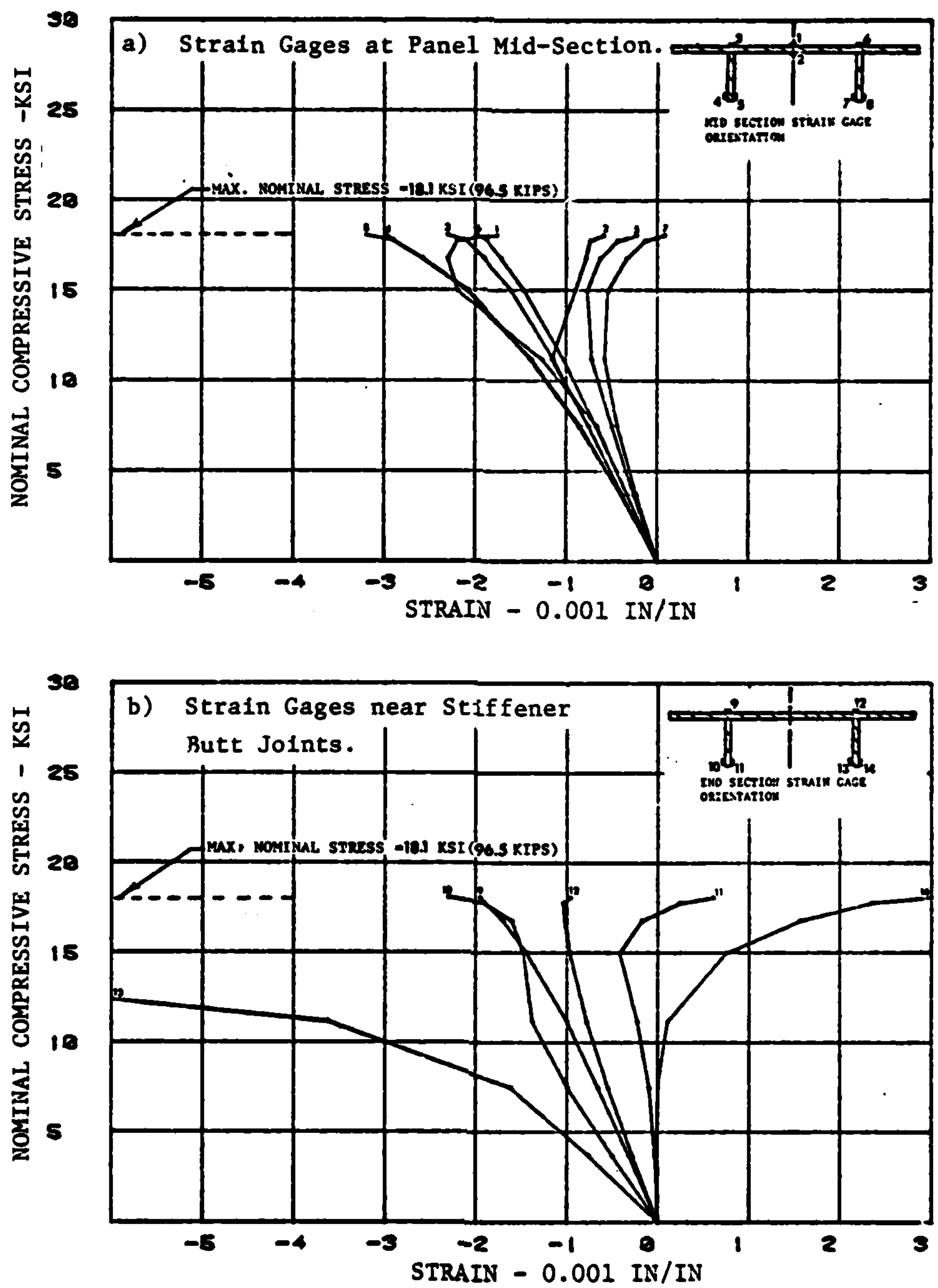


Figure 5-57. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-103-2 (Erection Joint "Light Scantling" Configuration with Stiffeners Misaligned and Laterally Bowed 1/4 Inch).

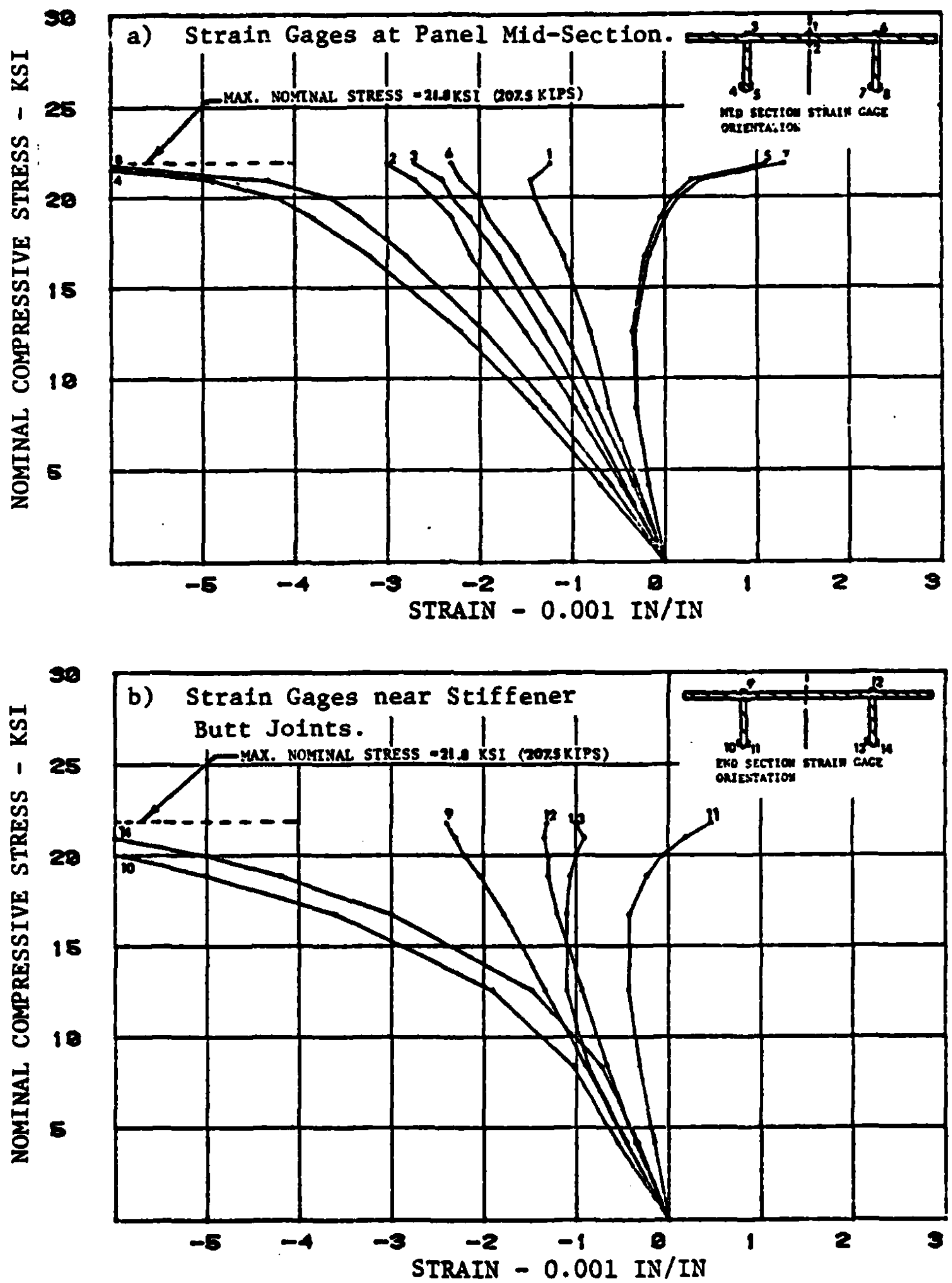


Figure 5-58. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-203-2 (Erection Joint "Average Scantling" Configuration with Stiffeners Misaligned and Laterally Bowed 1/4 Inch).

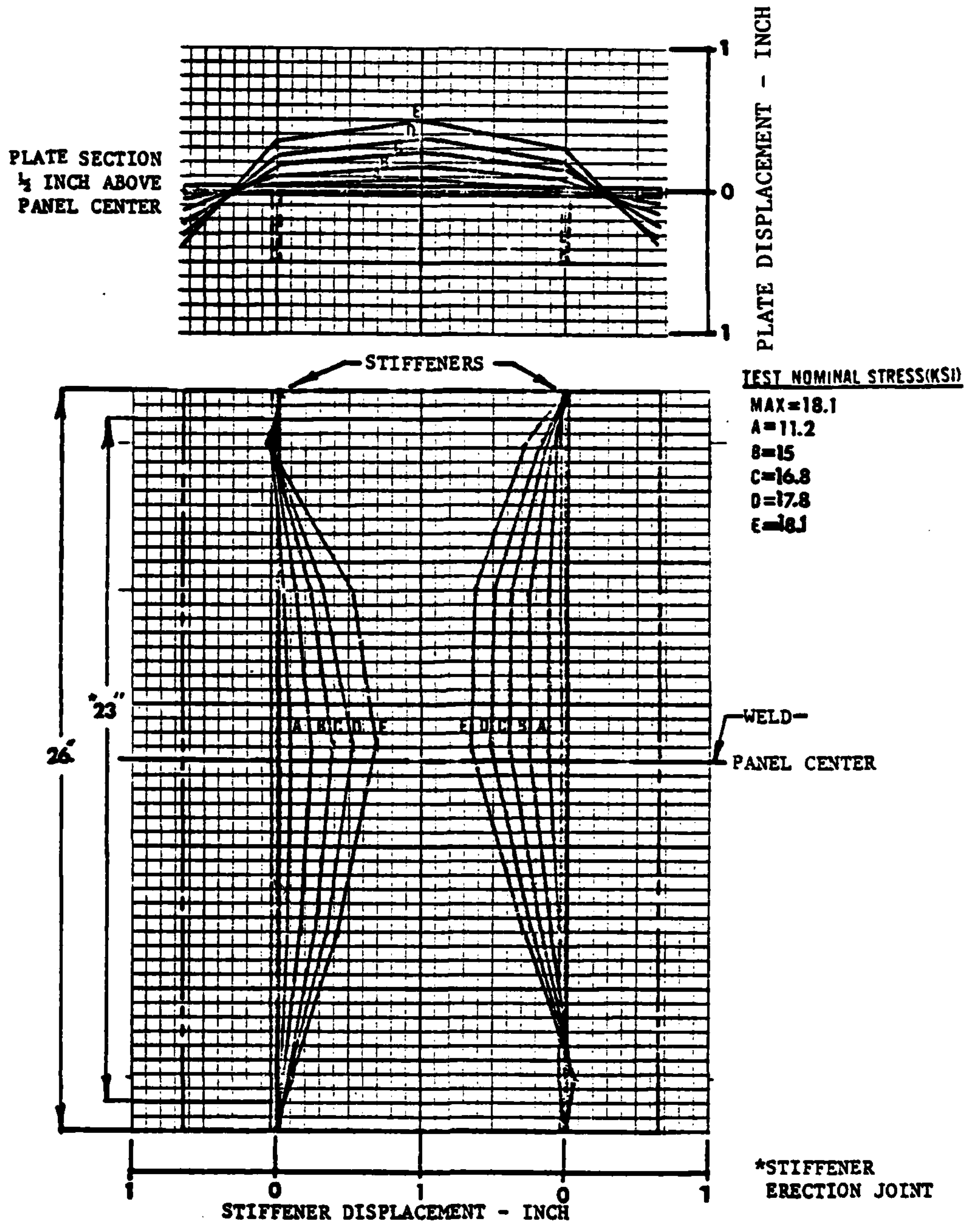


Figure 5-59. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-103-2.

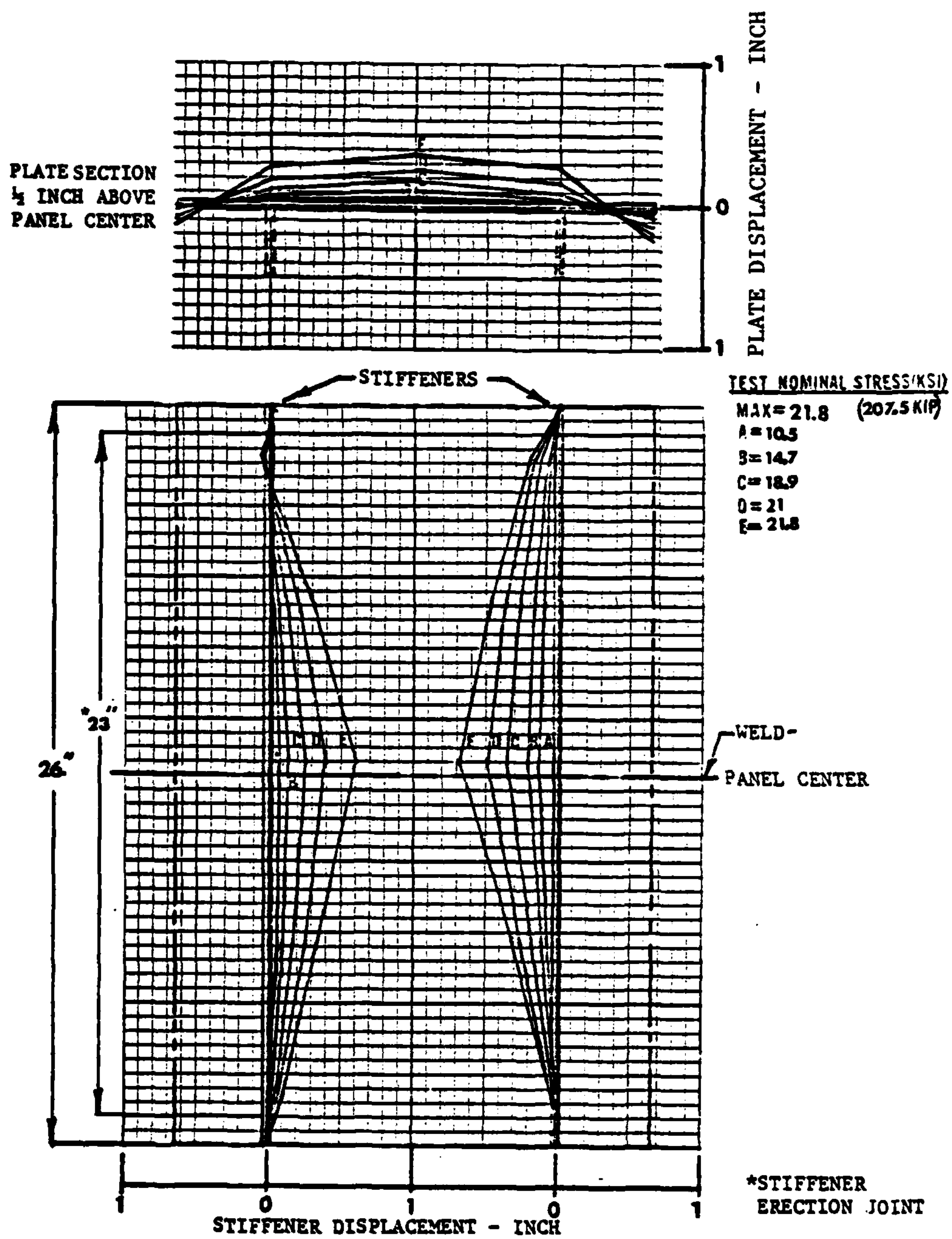
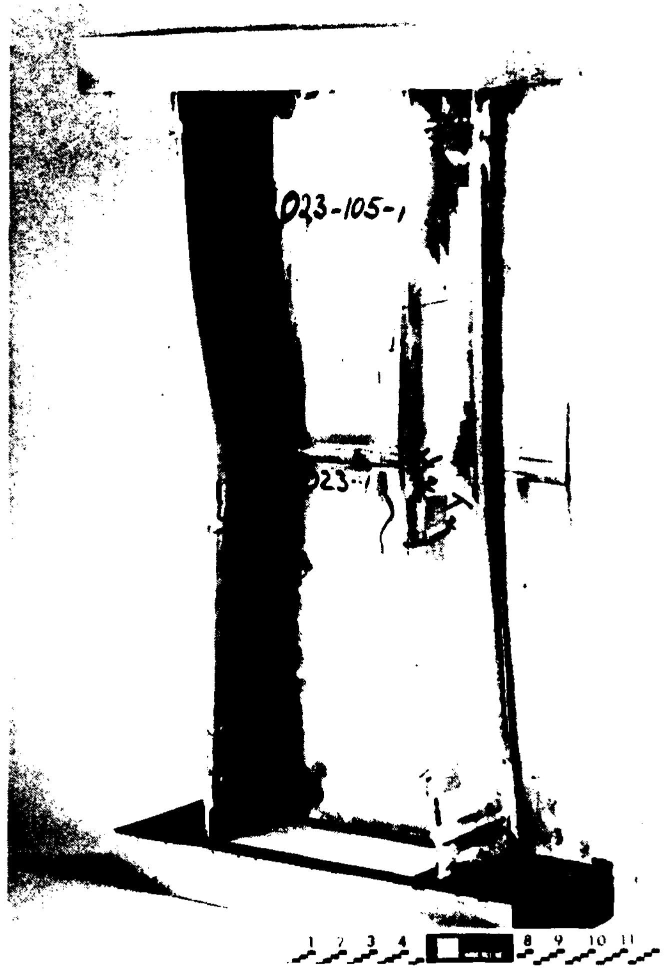


Figure 5-60. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-203-2.

(a) Specimen No. TT802023-105-1 (Thin Plate/ Stiffeners).



(b) Specimen No. TT802023-205-1 (Thick Plate/ Stiffeners).

Figure 5-61. Stiffened Panel Static Compression Tests Specimens After Failure - Erection Joint Configuration with Stiffeners Bowed 1/4 Inch

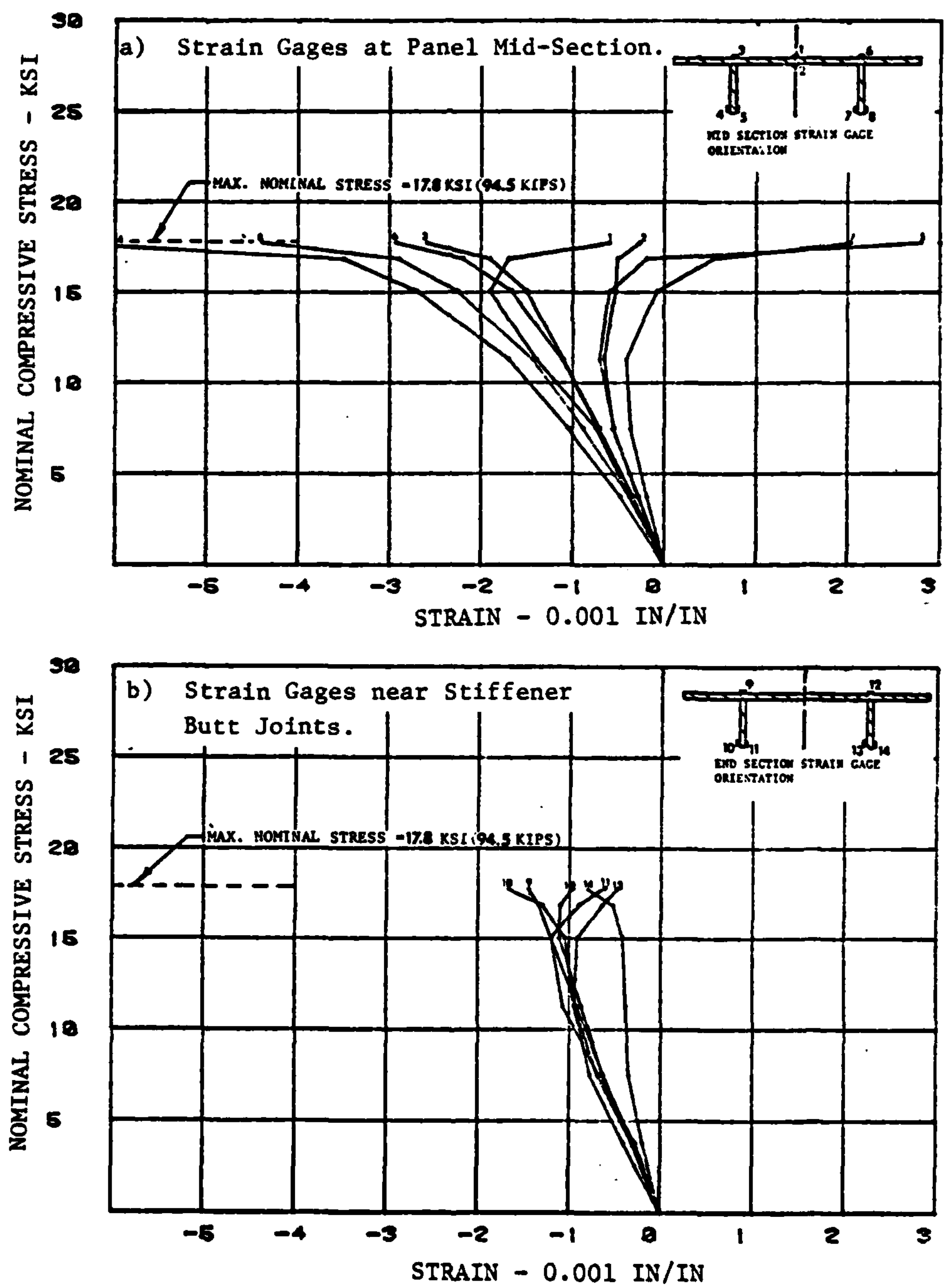


Figure 5-62. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-105-1 (Erection Joint "Light Scantling" Configuration with Stiffeners Laterally Bowed 1/4 Inch).

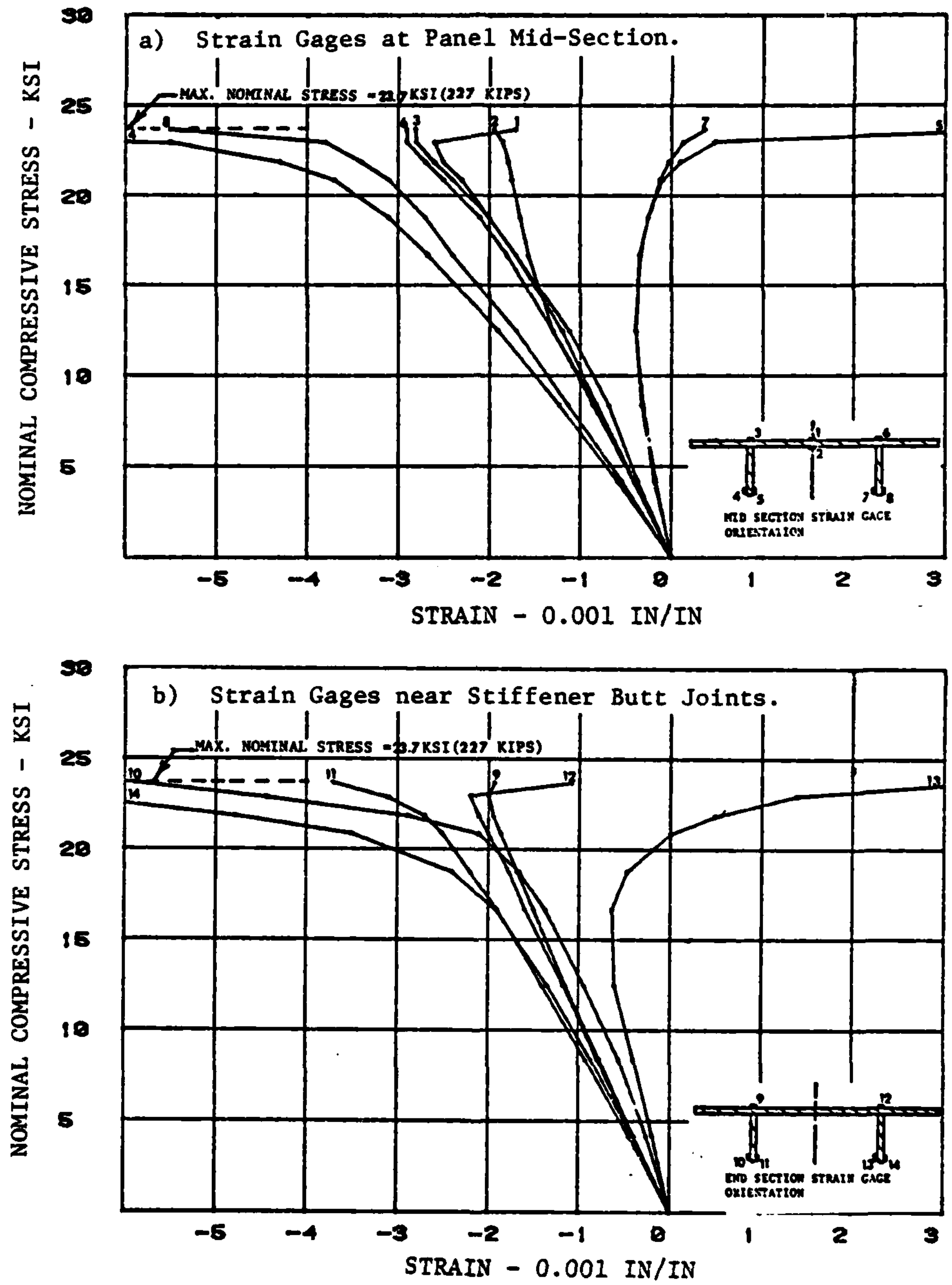


Figure 5-63. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-205-1 (Erection Joint "Average Scantling" Configuration with Stiffeners Laterally Bowed 1/4 Inch).

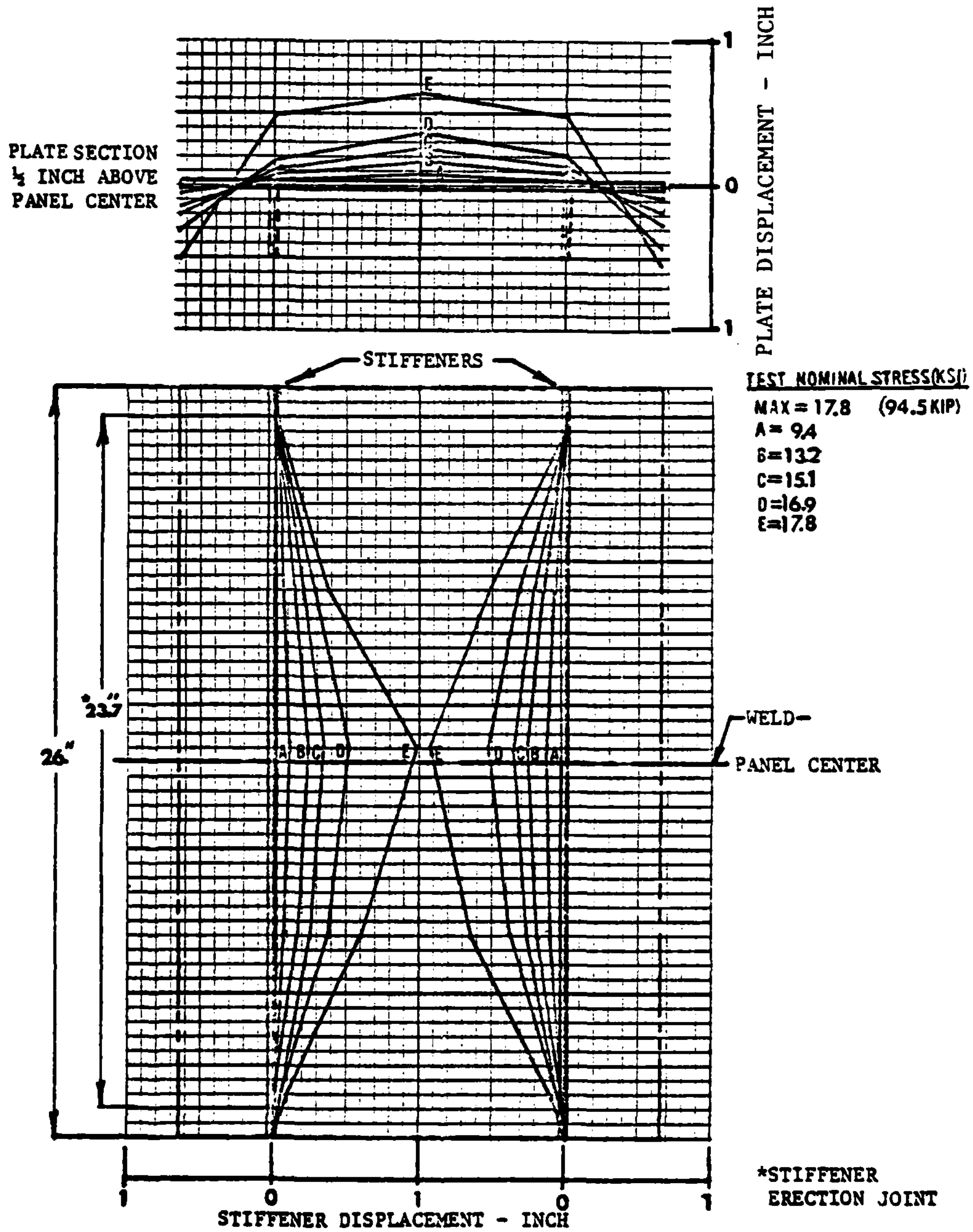


Figure 5-64. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-105-1.

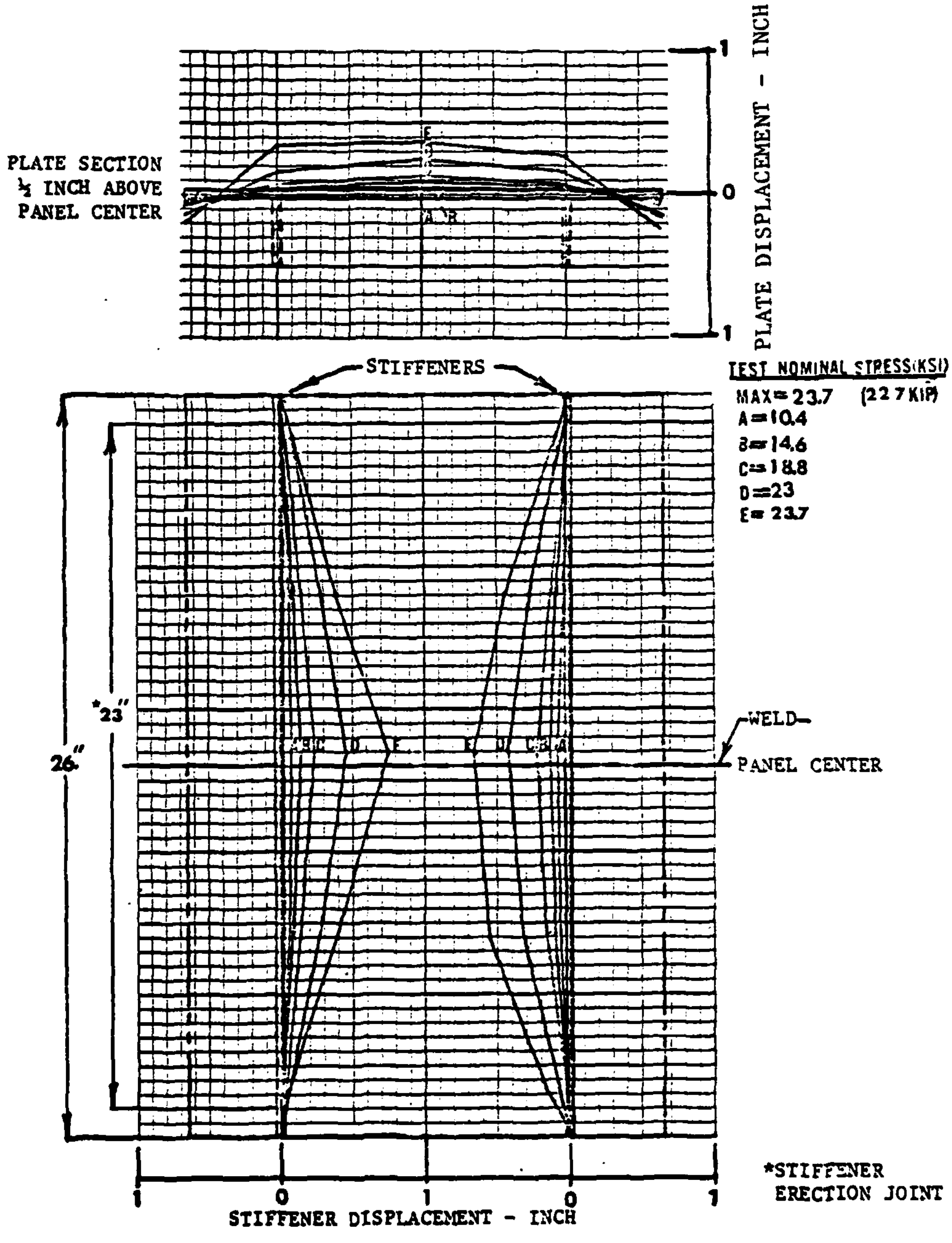


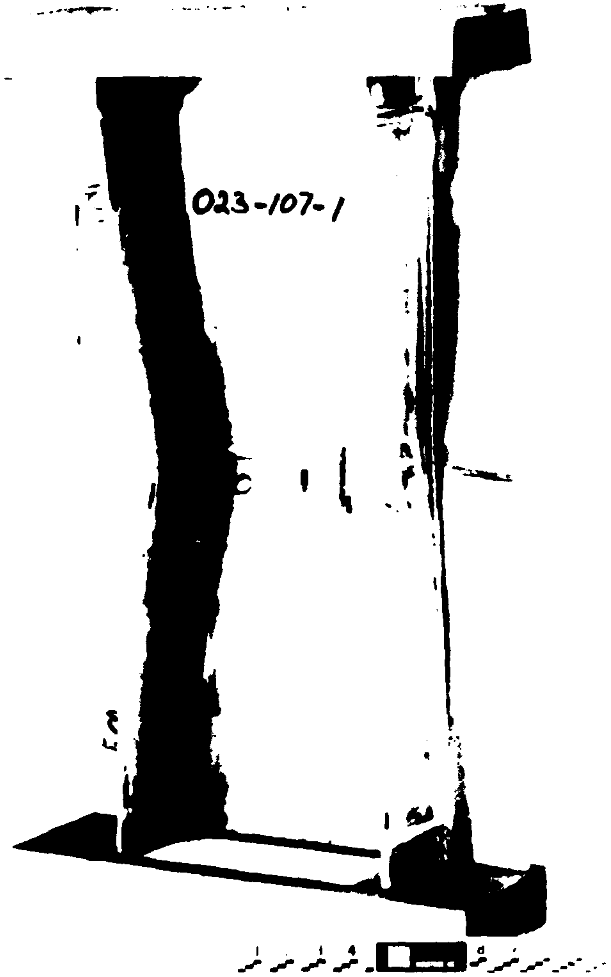
Figure 5-65. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-205-1.

the panel mid-section; the other "average" scantling specimen failed by stiffener bowing. The strength capability of these specimens was only slightly below that of the 1/4 inch bowed stiffener specimens described in Section 5.7.3.5 above. A typical failed specimen of each material thickness configuration is illustrated in Figure 5-66; strain and displacement plots are shown in Figure 5-67 through 5-70.

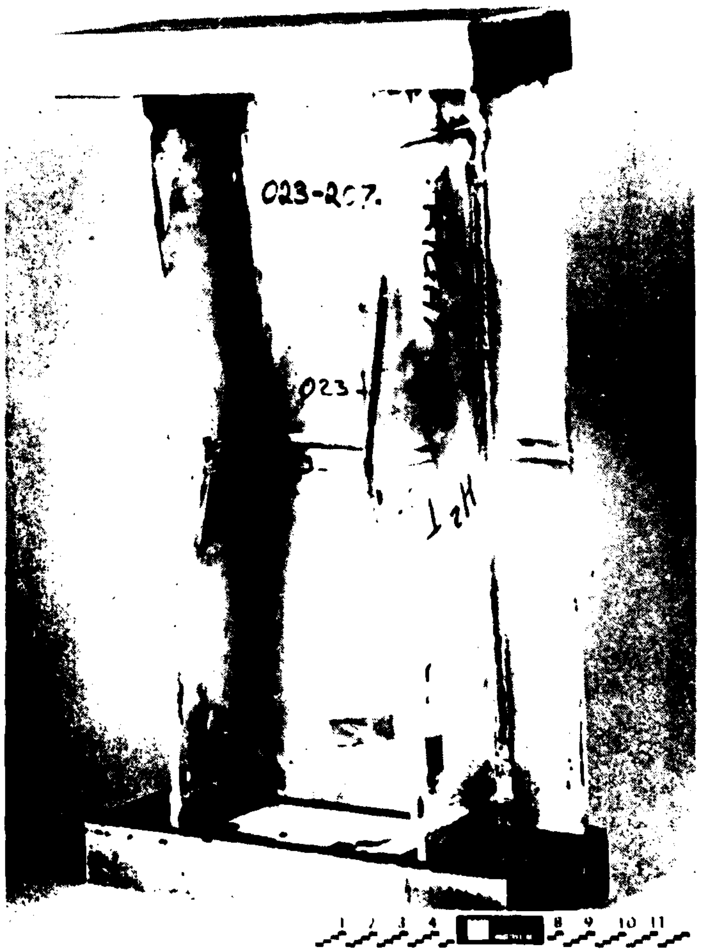
5.7.3.7 Test Results from Erection Joint Panels With Check-Stabilized Bowed Stiffeners -- These specimens were identical to the 3/8 inch bowed stiffener specimens described above except that chocks were installed between the stiffeners at the panel mid-section adjacent to the plate butt joint. All four of these specimens (TT802023-111-1/-2 and TT802023-211-1/-2) failed by stiffener buckling near the panel end. Buckling and failure stresses were consistent within each specimen thickness combination and the buckling/failure stresses were approximately 13% greater than the specimens without headers. A typical failed specimen of each material thickness configuration is illustrated in Figure 5-71; strain and displacement plots are shown in Figure 5-72 through 5-75.

5.7.3.8 Test Results from Erection Joint Panels With Riveted Stiffener Joints -- Two specimens fabricated from 0.281/0.250 inch plate/stiffener thicknesses with doublers riveted over unwelded stiffener butt joints were tested (TT802023-11-1/-2). This material thickness combination matched that for the baseline specimens (Reference Paragraph 5.7.3.1 above) except that the stiffeners were not haunched. Both riveted joint specimens failed by plate buckling near the specimen mid-span at approximately the same stress levels. A typical failed specimen is illustrated in Figure 5-76; strain and displacements are shown in Figure 5-77 and 5-78.

5.7.3.9 Discussion of Test Results -- The results of the stiffened panel compression tests are summarized in Figure 5-79. The average buckling and failure stress for each type of specimen is shown



(a) Specimen No. TT802023-107-1 (Thin Plate/ Stiffeners)



(b) Specimen No. TT802023-207-2 (Thick Plate/ Stiffeners).

Figure 5-66. Stiffened Panel Static Compression Test Specimens After Failure - Erection Joint Configuration with Stiffeness Bowed 3/8 Inch.

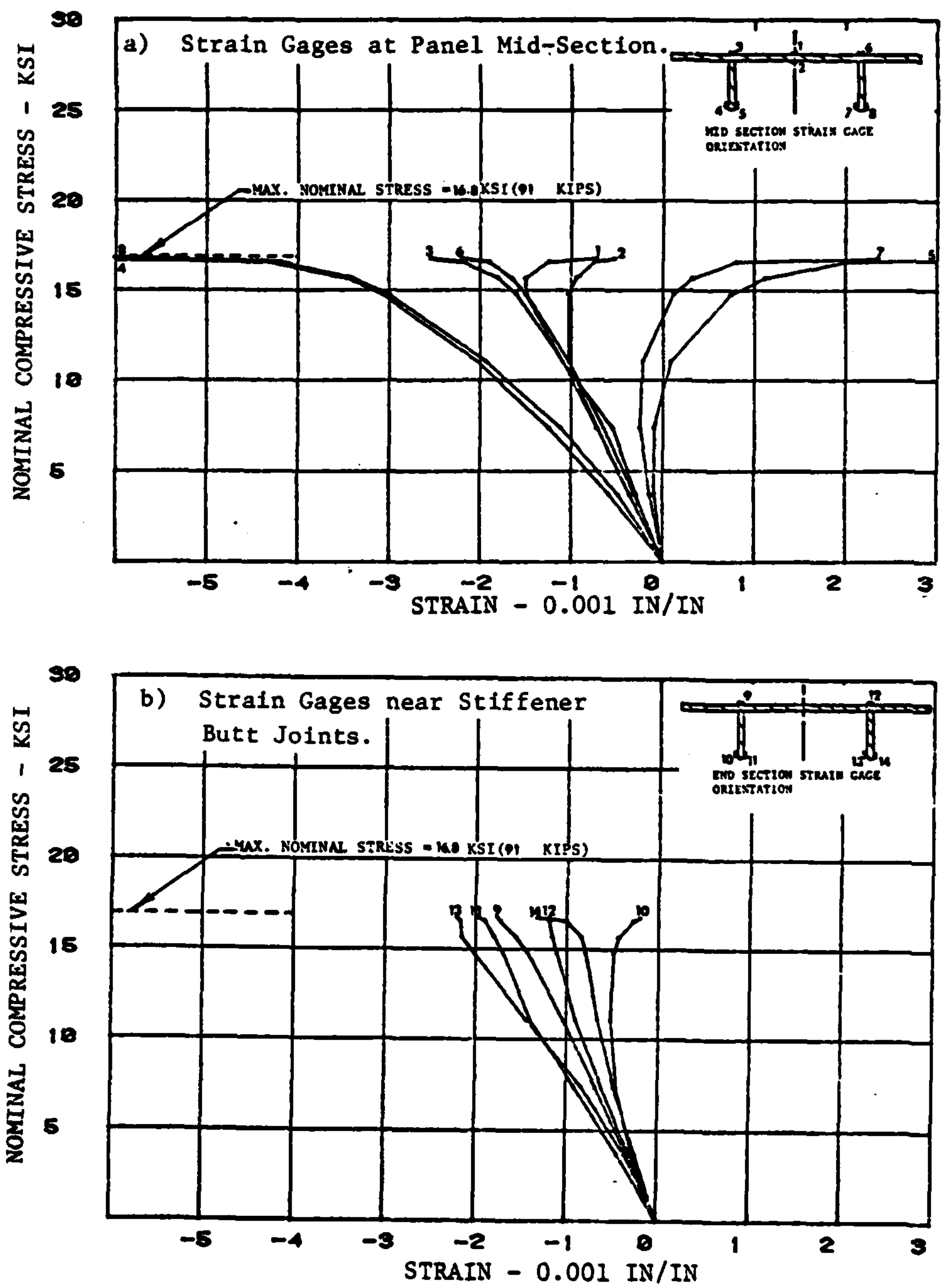
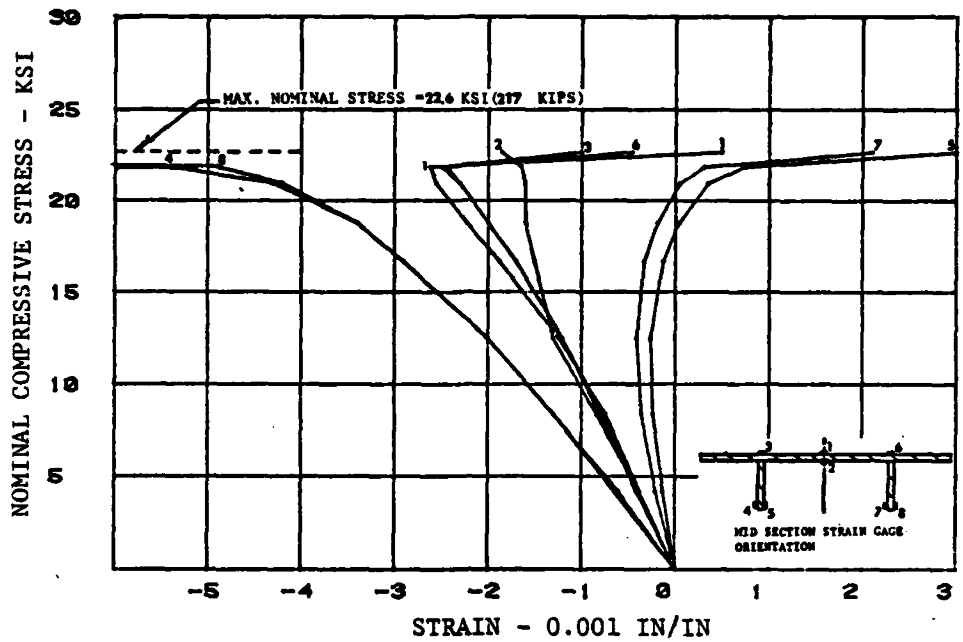


Figure 5-67. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-107-1 (Erection Joint "Light Scantling" Configuration with Stiffeners Laterally Bowed 3/8 Inch).



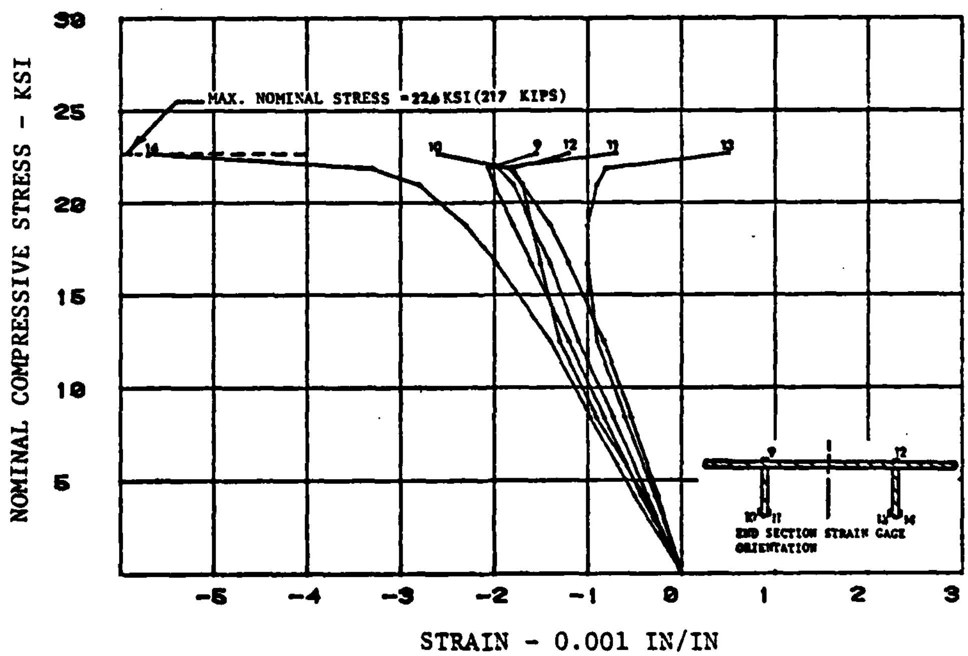


Figure 5-68. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-207-2 (Erection Joint "Average Scantling" Configuration with Stiffeners Laterally Bowed 3/8 Inch).

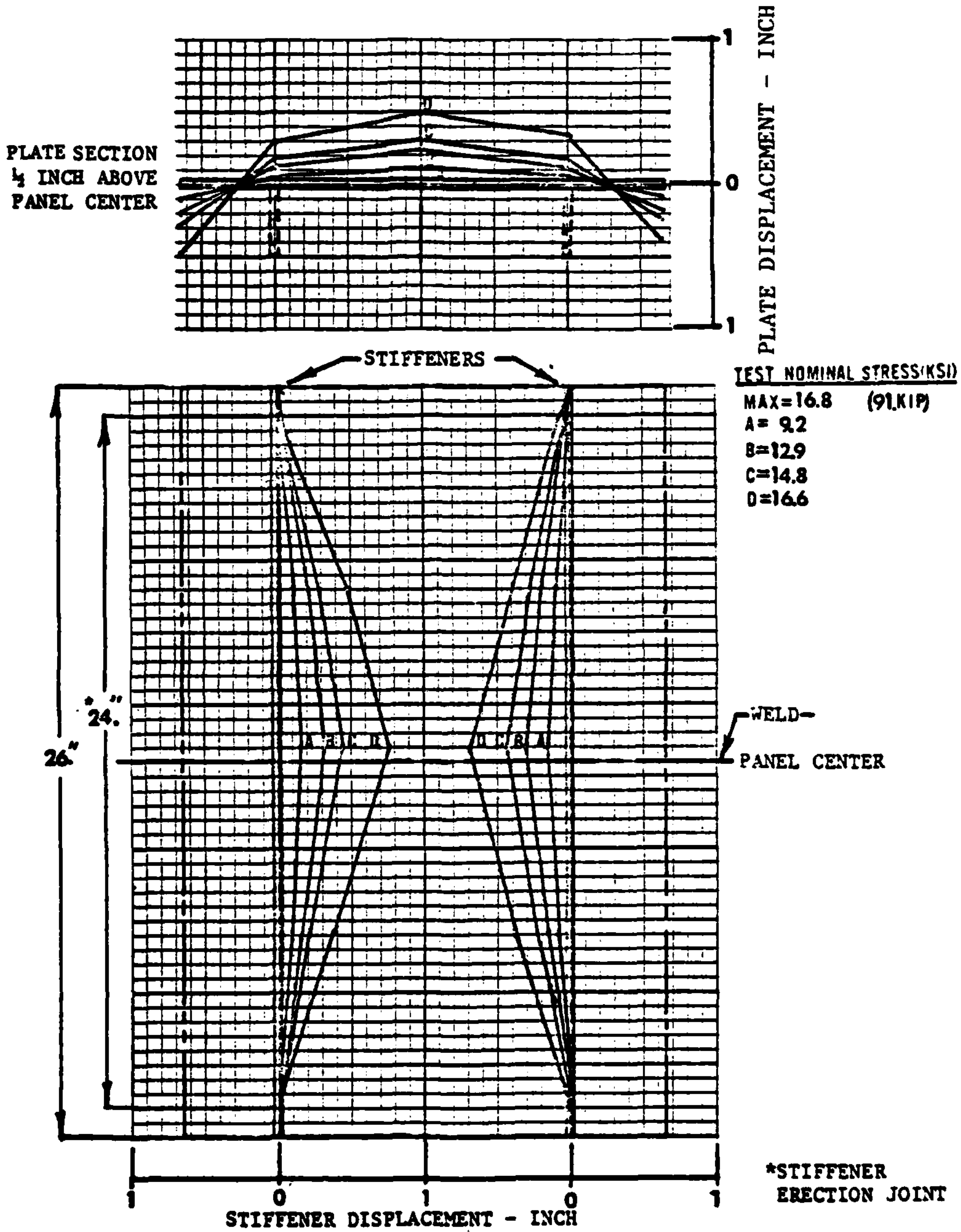


Figure 5-69. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-107-1.

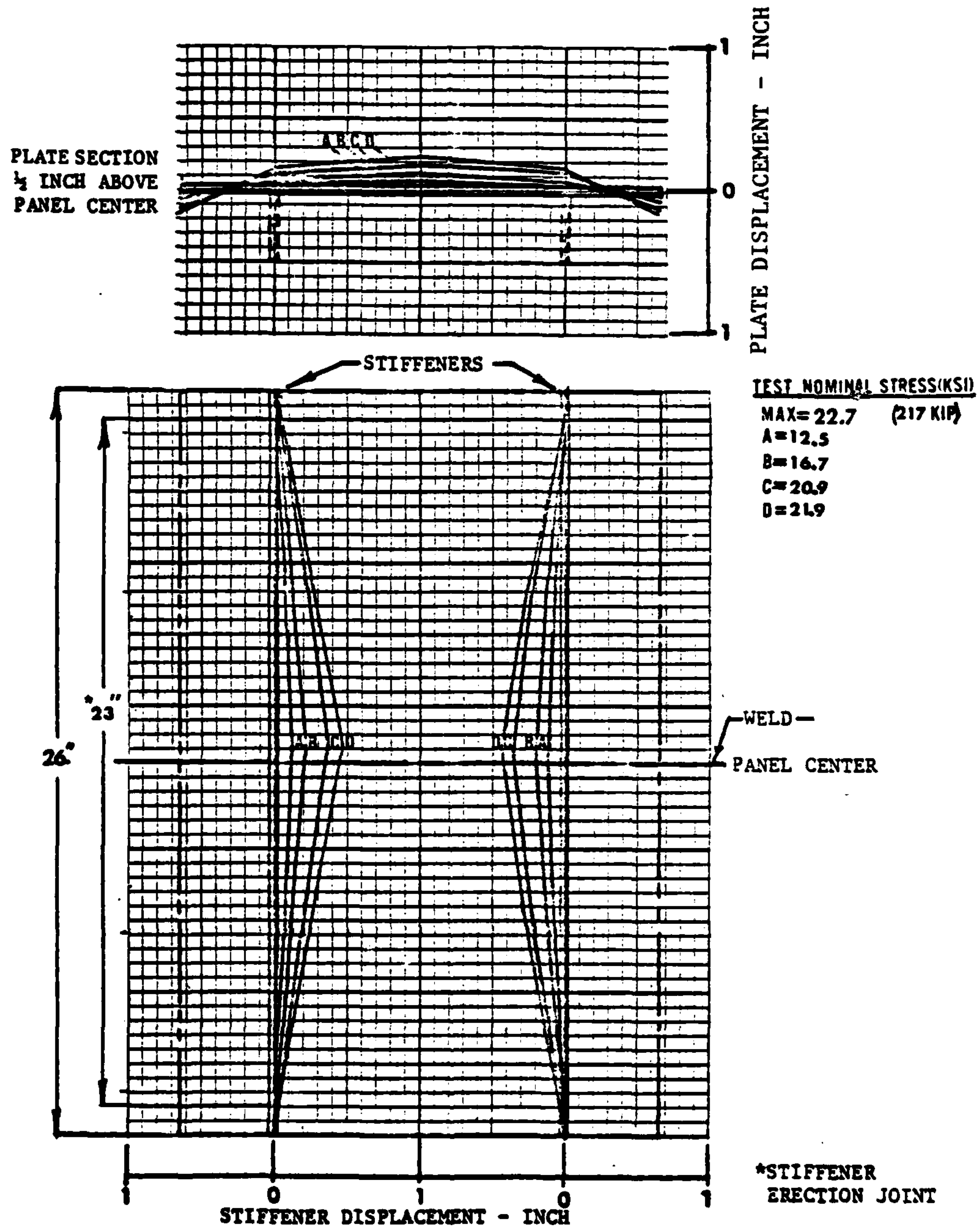
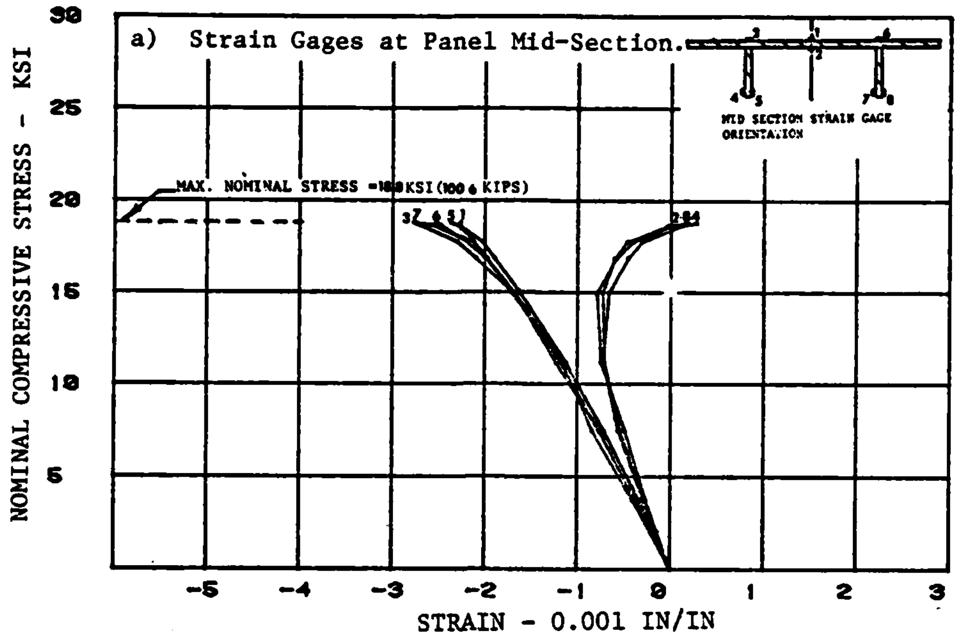


Figure 5-70. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-207-2.

(a) Specimen No. TT802023-111-2 (Thin Plate/ Stiffeners).

(b) Specimen No. TT802023-211-2 (Thick Plate/ Stiffeners.

Figure 5-71. Stiffened Panel Static Compression Test Specimens After Failure - Erection Joint Configuration with Chock-Stabilized Stiffeners Bowed 3/8 Inch.



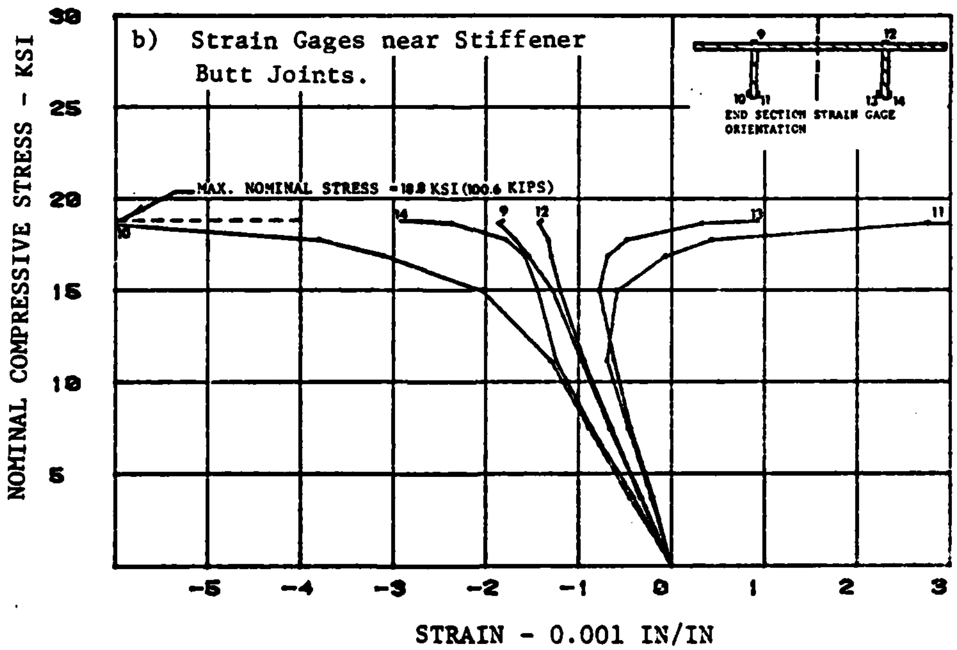


Figure 5-72. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-111-2 (Erection Joint "Average Scantling" Configuration with Stiffeners Laterally Bowed 3/8 Inch and Chock-Stabilized).

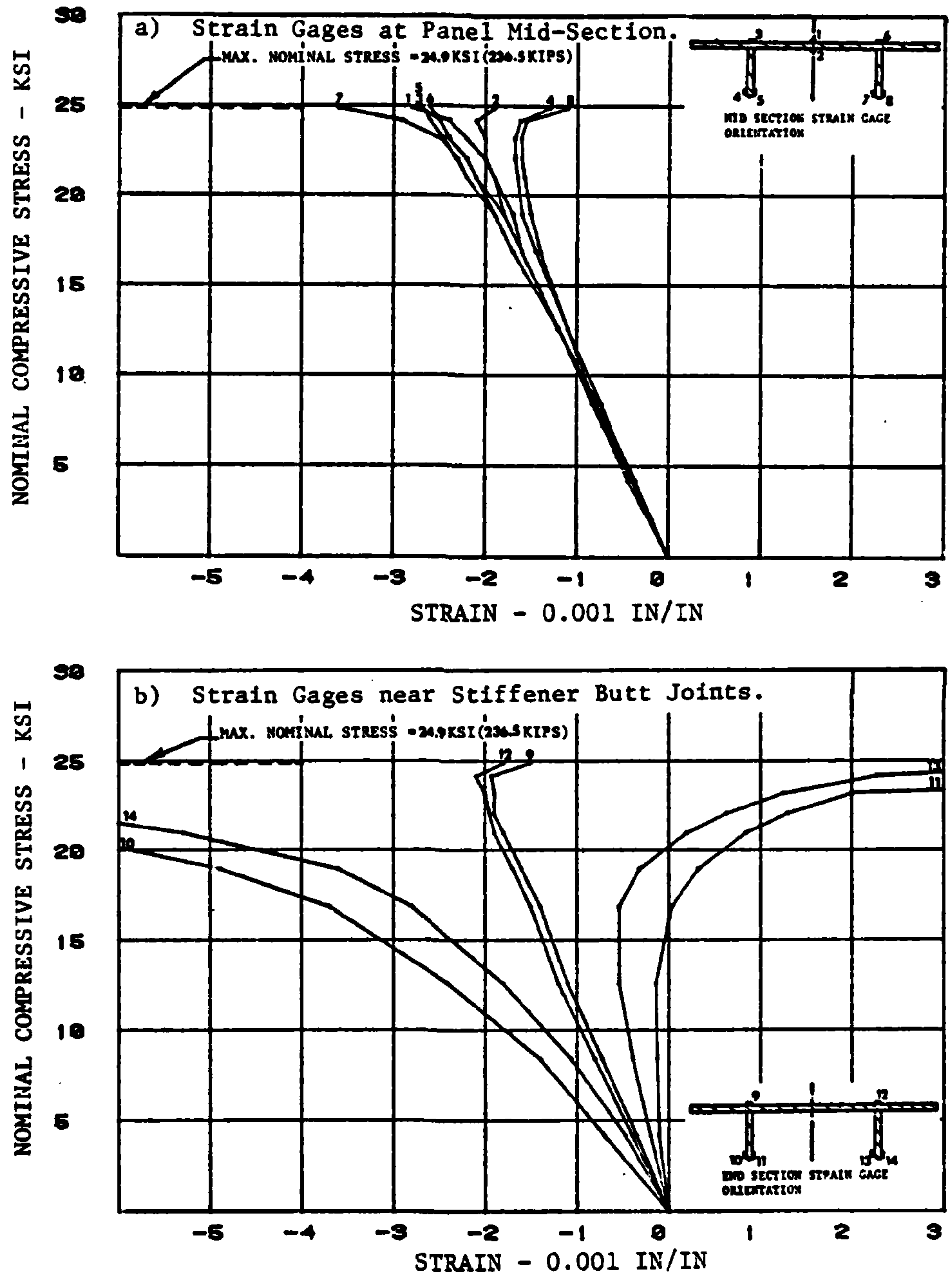


Figure 5-73. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-211-2 (Erection Joint "Light Scantling" Configuration with Stiffeners Laterally Bowed 3/8 Inch and Chock-Stabilized).

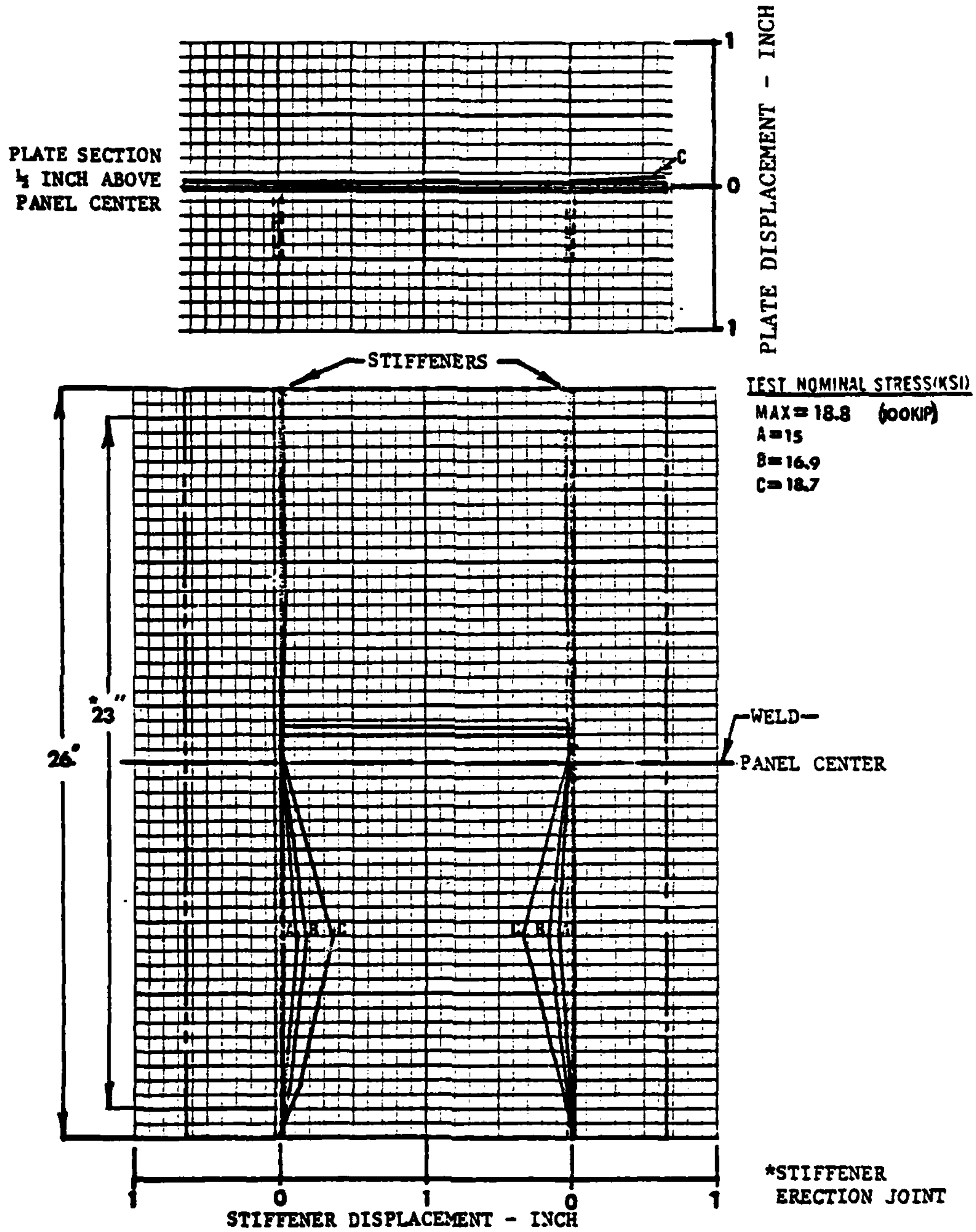


Figure 5-74. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-111-2.

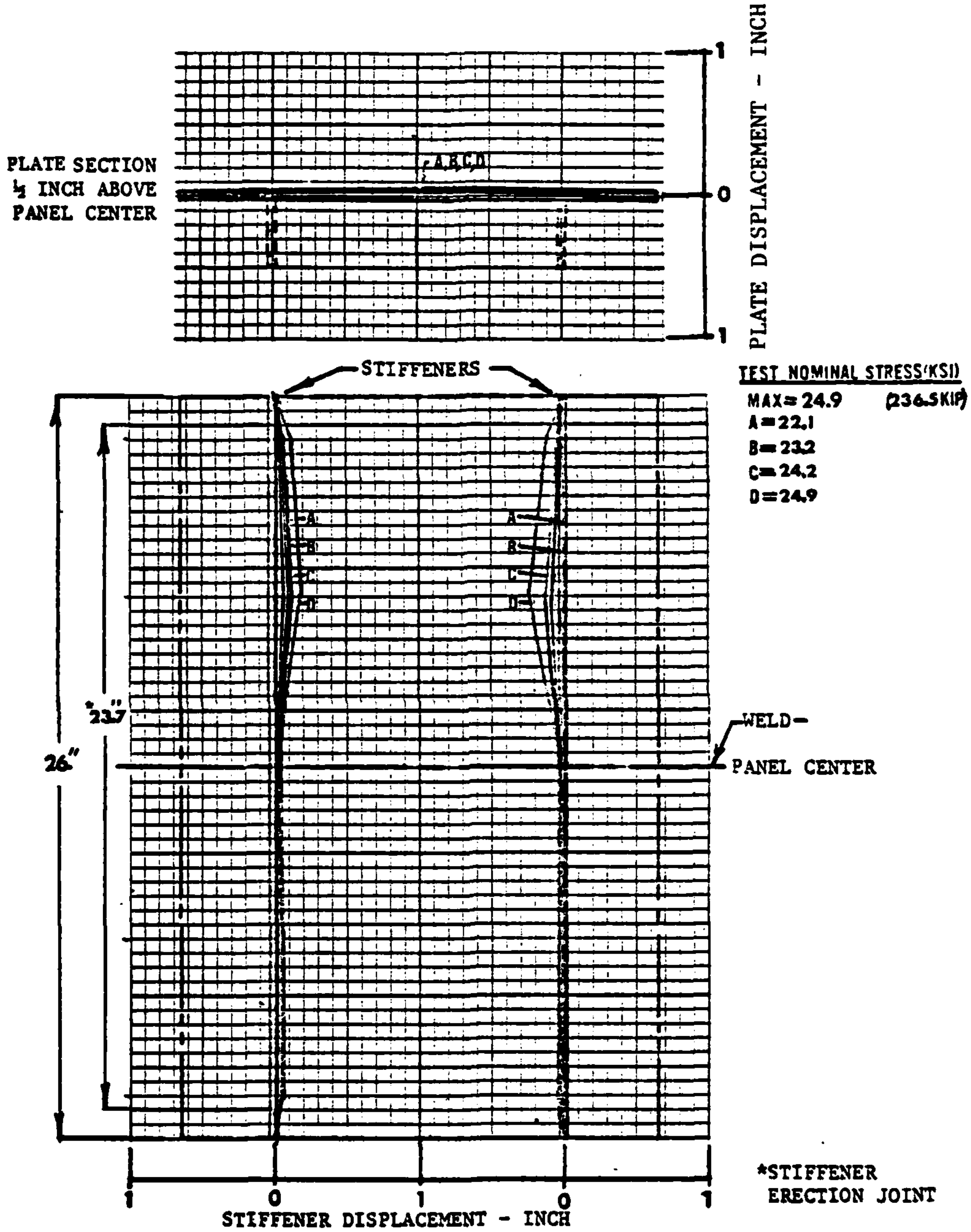
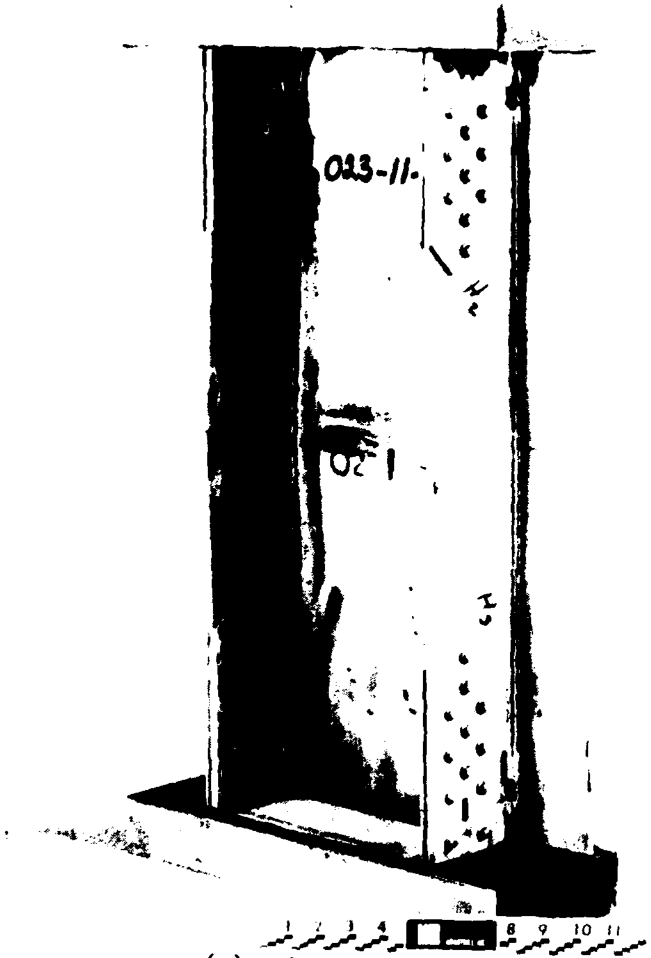
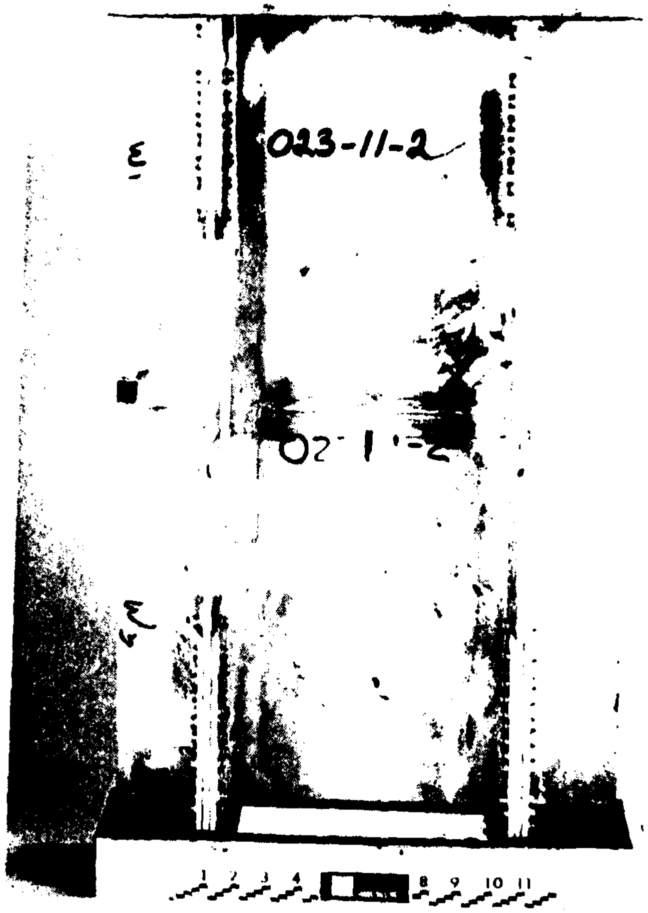


Figure 5-75. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-211-2.



(a) Oblique View



(b) Normal Veiw

Figure 5-76. Stiffened Panel Compression Test Specimen No. TT802023-11-2 Failure - Erection Joint Configuration with Riveted Doublers Across Unwelded Stiffener Joints.

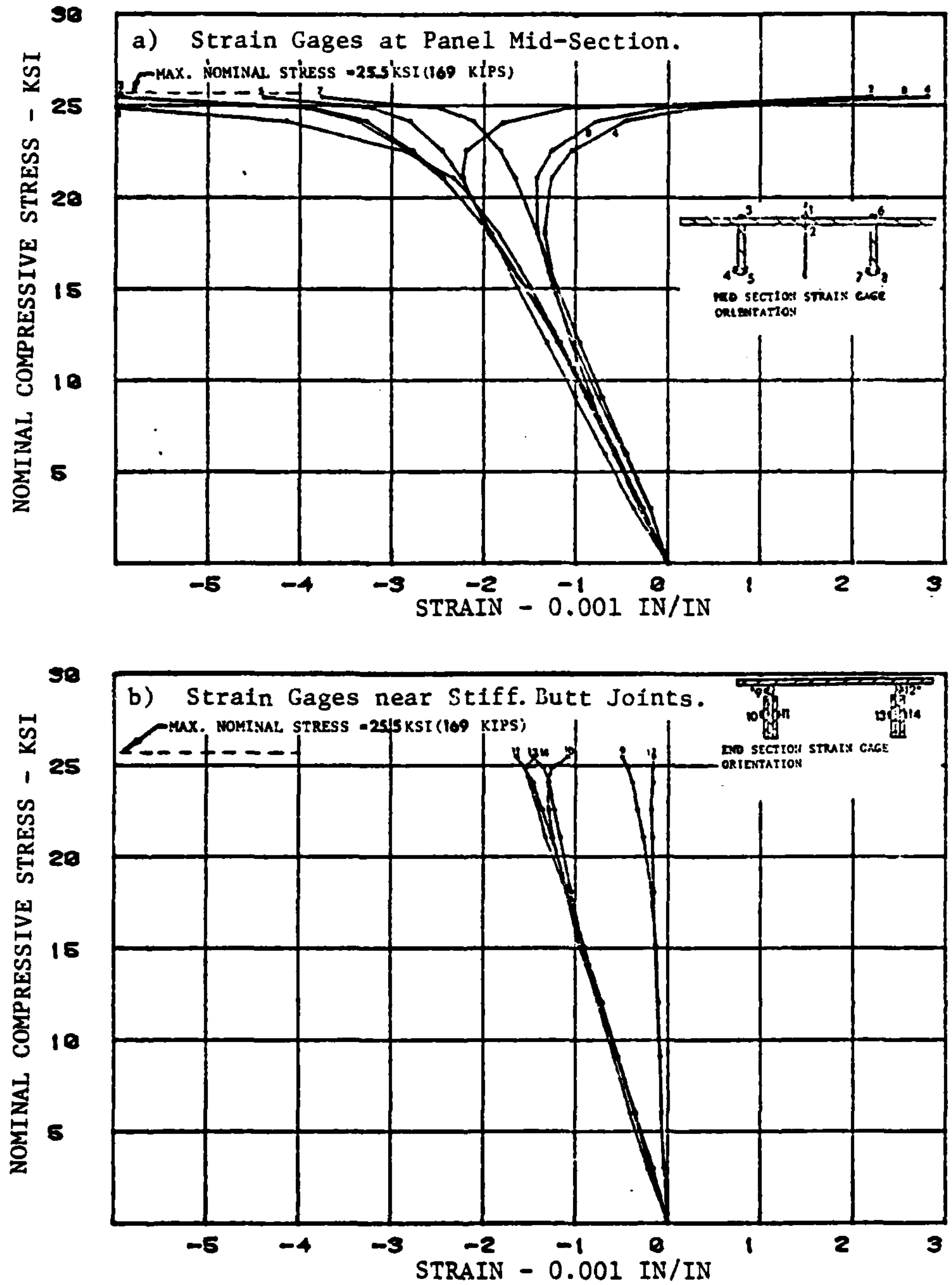


Figure 5-77. Stress-Strain Curves for Stiffened Panel Compression Test Specimen No. TT802023-11-2 (Erection Joint Configuration with Riveted Stiffener Butt Joints).

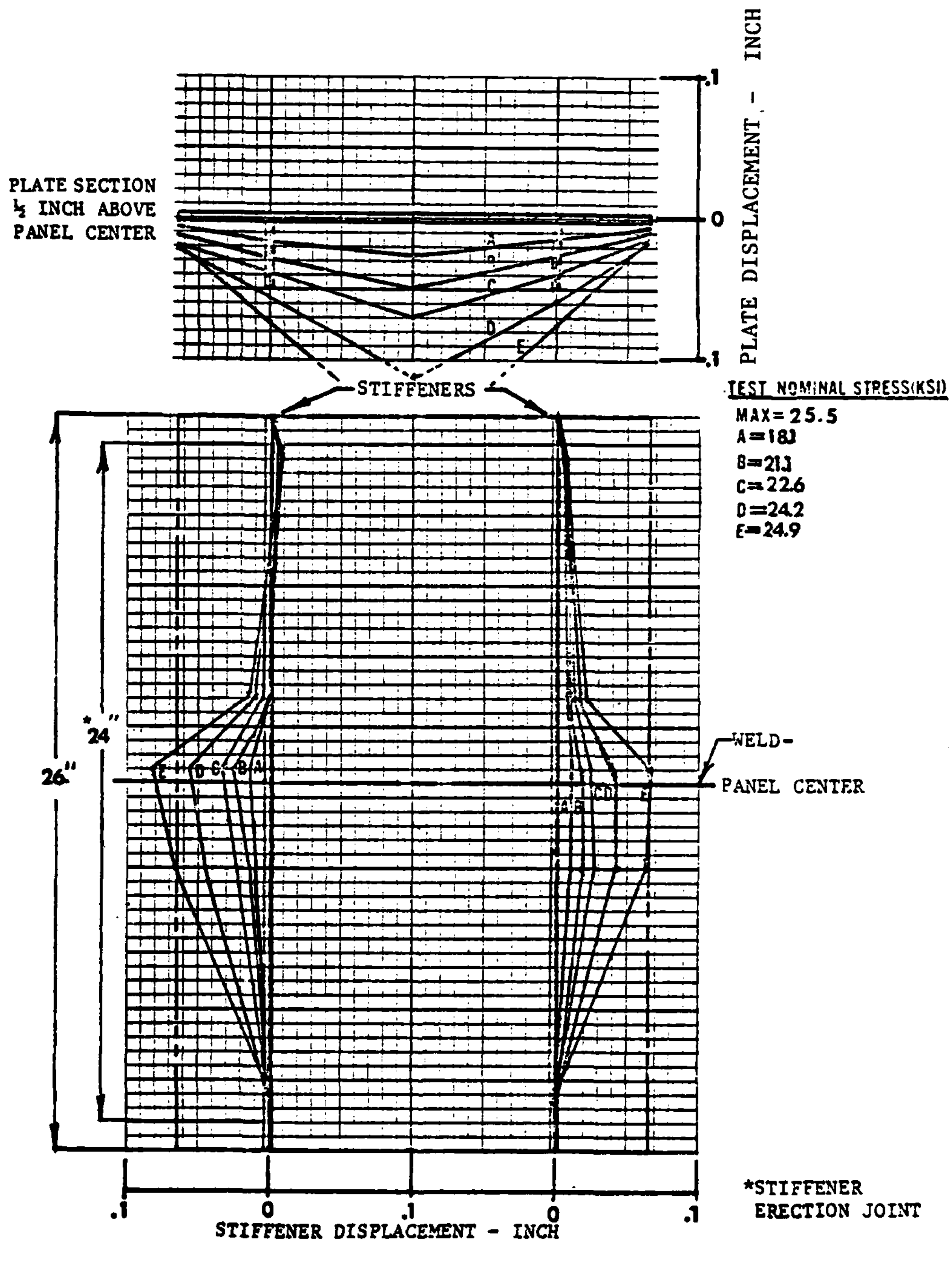


Figure 5-78. Deflection Curves for Stiffened Panel Compression Test Specimen No. TT802023-11-2.

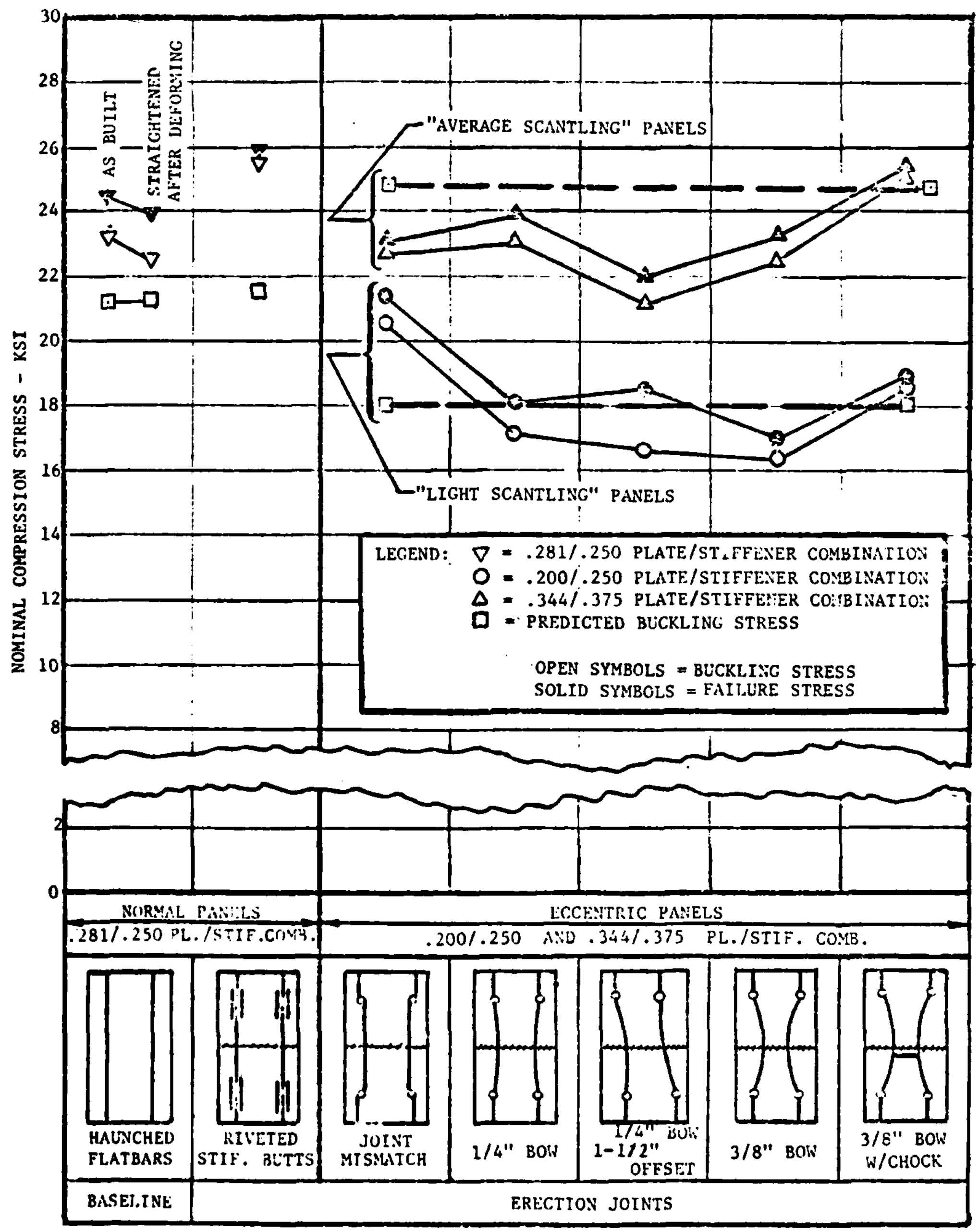


Figure 5-79. Averaged Results of Flatbar Stiffened Panel Axial Compression Tests.

along with the predicted buckling stress for each panel configuration. The predicted buckling stress was determined using the 3KSES bar-stiffened plating analysis program, described in Reference 18, with the column end fixity modified to reflect the pinended condition of the test specimens. Thus, the predicted buckling stress represents the allowable buckling stress for panels without geometric eccentricities and provides a baseline for evaluating the effect of the various eccentricities.

The buckling strength of the normal panels, as defined in Figure 5-79, and the panels with chock-stabilized bowed stiffeners was greater than the predicted buckling strength. Of the remaining specimens, only the "light" scantling panels with joint mismatch exceeded the predicted buckling strength. The remaining "light" scantling specimens buckled from 7.5% to 11.6% below the predicted value with the order of strength degradation progressing from the 1/4 inch bowed specimens to the 3/8 inch bowed stiffener specimens. The remaining "average" scantling specimens failed from 7.3% to 15.3% below the predicted value. For these configurations, the order of increasing strength degradation was panels with 1/4 inch stiffener bow, joint mismatch, 3/8 inch stiffener bow, and 1/4 inch stiffener bow with 1-1/2 inch stiffener offset misalignment.

5.8 CONCLUSIONS

This test program has produced significant information on the strength characteristics of stiffened panels which were fabricated in a production environment with dimensional tolerances equal to or greater than established production standards. Specific conclusions relative to the static tension, tension fatigue, and static compression strength characteristics, as determined from this test program, are presented in the following paragraphs.

5.8.1 STATIC TENSION -- These tests validate the existing design allowable tensile yield and tensile ultimate strengths for stiffened panel structural elements. The results demonstrate that the 3KSES welded material allowables are realistic for welded structures with practical tolerances. One of the welded erection joint specimens with excessive deviations from the fairness standards marginally achieved the allowable tensile ultimate strength. The specimens with bolted doublers barely achieved the allowable tensile ultimate strength; however, the failure was attributed to a marginal design of the fastener pattern. The measured average yield stress (32.8 ksi based on 10-inch gage length) indicates that the design allowable yield stress is conservative for stiffened panels with staggered stiffener/plate butt-welded joints.

5.8.2 TENSILE FATIGUE -- These conclusions are derived from the test results presented in Section 5.7.2 and are applicable to the specific welded stiffened panels as described in this report.

a. The stiffened panels with erection joints develop substantially lower axial fatigue strength than comparable types of butt welded plate coupons. This strength difference was attributed to elevated local stress conditions caused by steep or re-entrant butt weld reinforcement toe angles, discontinuities at the ends of fillet weld passes, weld lack of fusion imperfections, panel longitudinal bowing, and basic panel geometries.

b. The predominant mode of panel critical fatigue failure occurs at the stiffener butt welds.

c. Stiffened panel fatigue strength is significantly degraded by excessive butt weld toe angles and re-entrant angle conditions.

d. Straightening of longitudinally bowed panels is beneficial to fatigue strength.

e. Mismatched butt weld joints are detrimental to baseline panel fatigue strength. Mismatched butt welds are especially fatigue critical when a butt weld toe re-entrant angle condition is present.

f. Repaired panels have comparable strength to the baseline panel configuration.

g. Steep weld toe angles and excessively high reinforcements contributed to the weld repaired panel fatigue failures.

h. Panels with multiply repaired welds have fatigue performance degraded from panels with single repaired welds.

i. Flapper peening (with reinforcement contour fairing) of weld repairs is beneficial to the fatigue strength.

j. Doublers bonded over repairs exceed panel weld strength without repairs.

k. Doublers riveted over weld repairs do not improve fatigue strength over that of weld repairs alone.

l. Doublers riveted over unwelded stiffener butts eliminate the panel distortion longitudinal bowing caused by welding of these joints and result in a marginal improvement in fatigue strength over the welded baseline panels.

5.8.3 STATIC COMPRESSION -- The primary thrust of these tests was the evaluation of the effect of various geometric eccentricities which exceeded current production standards. Specific conclusions based on these tests are as ollows:

a. Panels with the 0.200/0.250 inch plate/stiffener thickness combination welded with joint mismatch which exceeded production standards by up to 100 percent exhibited buckling strength approximately 8 percent below predicted values.

b. Both types of panels with stiffeners bowed 1/4 inch (i.e., 1/16 inch greater than production standards) failed to achieve the predicted buckling strengths by five percent and seven percent for the "light" and "average" scantlings, respectively. These reduced values may be used to substantiate acceptance of similar production welds based on the results of stress analysis.

c. Both types of panels with 1/16 excess bow and 1 1/2 inch offset misalignment of the stiffeners across the erection joint failed to achieve the predicted buckling strengths by 8 percent and 15 percent for the "light" and "average" scantling specimens, respectively. Since the amount of offset in the specimens exceeded the allowable offset by a factor of 2 for the "light" scantling specimens and 1.6 for the "average" scantling specimens, these results may be used in conjunction with stress analysis to justify the acceptance of similar production welds with misalignment within production standards.

d. Both types of panels with 3/8 inch bow in the stiffeners (i.e., twice that permitted by production standards) failed to meet predicted values by 9 percent.

e. Both types of panels with chock-stabilized 3/8 inch bowed stiffeners at values slightly above those predicted, thereby substantiating this method as an acceptable repair.

f. The test results from the haunched flatbar baseline panel validate the configuration of these panels and the method of analysis. These results also show little or no degradation of strength resulting from the bowing and straightening operation.

g. The panels with doublers riveted over unwelded stiffener butt joints reach buckling strength considerably (17 percent) above the predicted value. This increase strength results

from an effective shortening of the flatbar columns due to the added stiffness of the doublers at the ends. This effect was demonstrated by the failure mode, plate buckling, for both of these specimens.

The stiffened panel compression buckling test results have demonstrated the effect of the various panel eccentricities and validate the method of analysis. The results of the tests of the eccentric panels provide data which may be used, in conjunction with stress analysis, to provide a basis for evaluation and disposition of excessive eccentricities which may occur in 3KSES stiffened panel structure.

6 / DECK/BULKHEAD TESTS

6.1 GENERAL

Testing of specimens which represented continuous deck structure intersecting with a transverse bulkhead on the 3KSES constituted the initial phase of element tests under the Panel and Element Structural Test Program. These tests were conducted in full accordance with Test Plan No. TTP00017, Reference 2, except for minor deviations explained herein.

The deck/bulkhead element tests were conceived to be a logical advancement from the stiffened panel tests described in Section 5 of this report. As such, the deck/bulkhead element tests were designed to evaluate two areas of interest. These areas were the watertight penetration of continuous deck structure through a transverse bulkhead and the region of the ship erection joint. The ship erection joint area was included to provide direct correlation to the results obtained from tests conducted on stiffened panels incorporating the same erection joint configuration.

A total of five deck/bulkhead element test specimen assemblies were fabricated. Two specimens were subjected to static tensile tests and three to tensile fatigue tests as described in detail below.

6.2 SPECIMEN DESCRIPTION

All five of the deck/bulkhead element test specimens were fabricated as replicates of one configuration. This configuration represented the watertight penetration of continuous deck structure through a major transverse bulkhead on the 3KSES and included the adjacent ship erection butt area. A sketch of the deck/bulkhead test specimen with nominal scantlings and dimensions is presented in Figure 6-1. As shown in this figure, each specimen consisted of two tee-stiffened plates, simulating sections of transverse bulkhead, joined to opposite sides of a flatbar stiffened plate deck structure. In order to obtain comparative data, the nominal scantlings shown in Figure 6-1 for the deck structure duplicated the scantlings of the tensile static and fatigue test stiffened panels described in Section 5. In addition, the erection butt joints in each deck/bulkhead specimen were fabricated with nominal mismatch duplicating that in the corresponding stiffened panel specimens (Reference panel specimens no. TT802022-11).

The individual deck/bulkhead specimens were all obtained from a single large welded assembly manufactured by RMI Production per Drawing No. TT802032 (Reference Appendix A). This assembly was fabricated from 5456-H116 or H117 aluminum alloy sheet and plate gas-metal-arc welded with type 5556 aluminum alloy filler wire using machine and semi-automatic welding methods. The basic fabrication of the large assembly was performed to simulate the planned 3KSES assembly and erection sequence. As such, two deck subassemblies and two transverse bulkhead subassemblies were initially produced. The two bulkhead assemblies were then joined to the larger deck subassembly to represent the ship structure forward of a major assembly erection joint. The sequence employed for attaching the smaller deck assembly duplicated the planned procedure for ship erection of major assemblies. Except for the specified erection butt joint mismatch, all components were aligned, fit-up and constrained during welding in a manner similar to that planned for 3KSES production. Required post weld straightening was successfully accomplished using selected patterns of surface shrink welds. The large

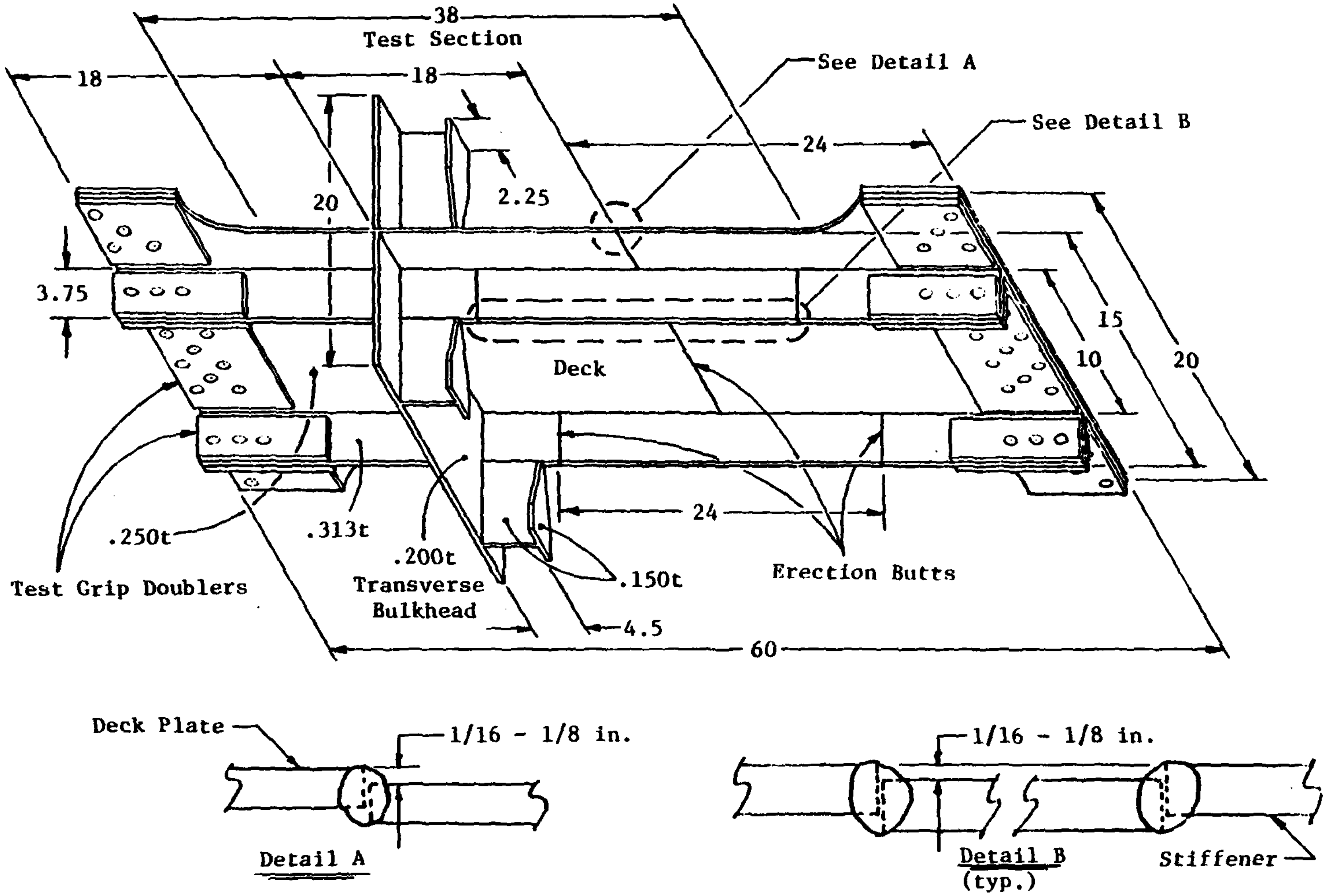


Figure 6-1. Deck/Bulkhead Element Test Specimen Configuration

welded assembly was fully inspected and accepted to the requirements of Drawing No. TT802032 by Quality Assurance. A photograph of this assembly is shown in Figure 6-2.

The balance of fabrication on the five individual deck/bulkhead element test specimens was performed by the Rohr Industries Test Laboratory per RMI Drawing No. TT802033 (Reference Appendix A). Each specimen was first parted from the large weld assembly and final trimmed to contour using templates and a router. Aluminum doublers were then adhesive bonded to the deck plate and stiffeners at both ends. Specimen fabrication was completed by drilling the grip attachment hole patterns utilizing drill fixtures fabricated per RMI Drawings No. TT802028 and TT802029 (Reference Appendix A). On the three specimens scheduled for fatigue testing, a final hand finishing and polishing operation was performed to remove burrs and nicks from the deck and bulkhead plate edges through the test section zone. A photograph of a deck/bulkhead element specimen ready for test is presented in Figure 6-3.

6.3 SPECIMEN PREPARATION

Prior to test, each deck/bulkhead element specimen was accurately measured at the locations depicted in Figure 6-4. Measurements were also made to quantify the amount of deck longitudinal bowing distortion present in each of the three specimens scheduled for fatigue testing. The need for these measurements was not established until after initial testing had been performed on the two static test specimens. All recorded measurements obtained from each specimen are presented in Table 6-1.

After measurements were completed, each specimen was instrumented with strain gages. Locations, orientations and other details of the strain gage installations are presented in Section 6.5 below. On the two deck/bulkhead element specimens scheduled for static tensile testing, percentage elongation reference points were punch marked on opposite sides of each weld joint at 2 inch and 10 inch gage lengths as indicated

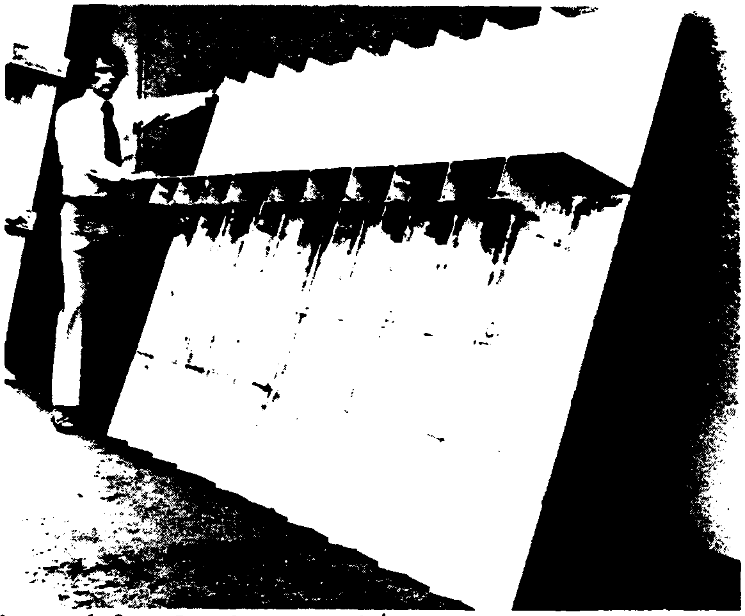


Figure 6-2. Completed Deck/Bulkhead Production Welded Assembly.

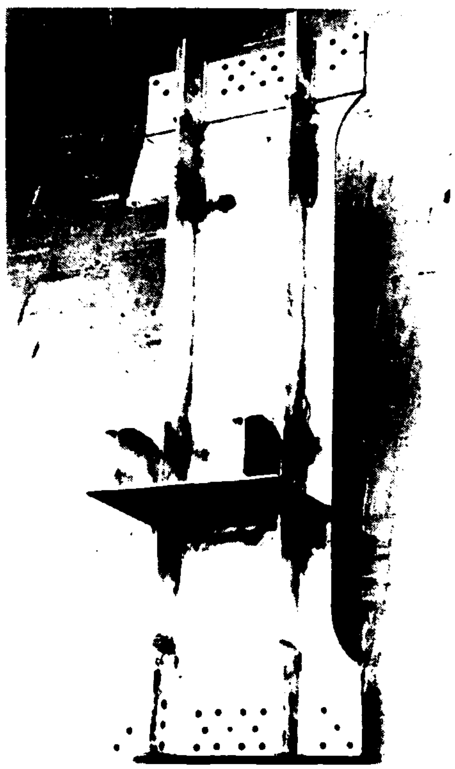
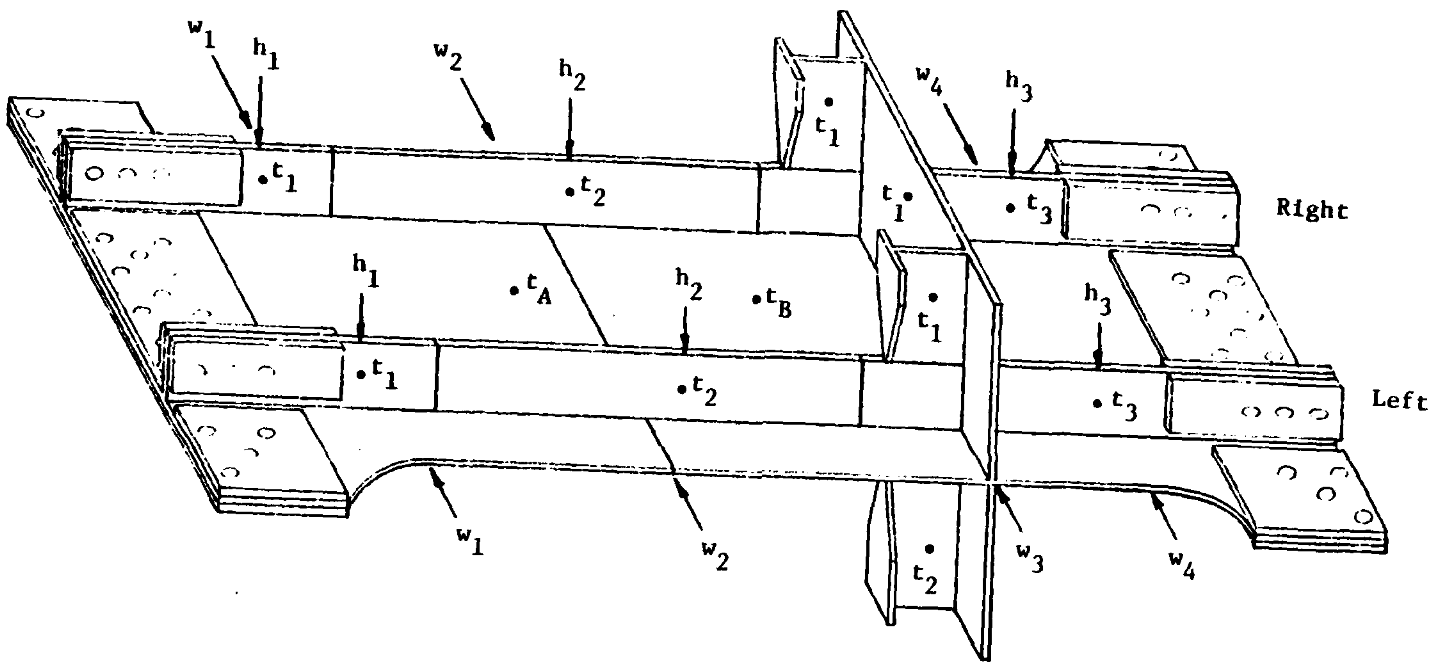


Figure 6-3. Completed Deck/Bulkhead Element Test Specimen



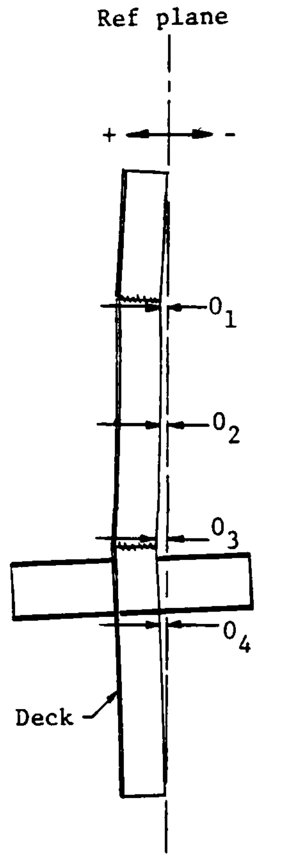
LEGEND: t - Stiffener or plate thickness
w - Plate width
h - Stiffener height

Figure 6-4. Deck/Bulkhead Element Specimen Pretest Measurement Locations.

Table 6-1. Deck/Bulkhead Element Specimen Pretest Measurements.

NOTE: Reference Figure 6-4 for measurement locations and identifications except those shown on the sketch below.

Component	Dimen.	Element No. TT802033				
		(Static)		(Fatigue)		
		-1-S1	-1-S2	-1-F1	-1-F2	-1-F3
Deck Plate	t_A	.261	.260	.260	.262	.262
	t_B	.262	.262	.261	.265	.254
	w_1	14.973	14.975	14.975	14.980	14.984
	w_2	14.963	14.964	14.965	14.962	14.970
	w_3	14.961	14.968	14.958	14.965	14.975
	w_4	14.963	14.968	14.975	14.965	14.975
Deck Left Stiff.	t_1	.311	.310	.312	.312	.311
	h_1	3.773	3.826	3.736	3.738	3.780
	t_1	.316	.316	.313	.314	.317
	h_2	3.742	3.742	3.722	3.720	3.780
	t_3	.319	.317	.318	.318	.317
	h_3	3.704	3.698	3.688	3.713	3.722
	O_1	NR	NR	.273	.177	.120
	O_2	NR	NR	.242	.160	.110
	O_3	NR	NR	.308	.134	.192
	O_4	NR	NR	.223	.125	.142
Deck Right Stiff.	t_1	.312	.312	.312	.312	.311
	h_1	3.783	3.753	3.760	3.770	3.770
	t_2	.315	.318	.316	.316	.317
	h_2	3.726	3.698	3.718	3.718	3.738
	t_3	.315	.319	.319	.315	.315
	h_3	3.722	3.733	3.690	3.700	3.700
	O_1	NR	NR	.170	.212	.097
	O_2	NR	NR	.191	.193	131
	O_3	NR	NR	.277	.248	.255
	O_4	NR	NR	.188	.185	.172
Bulkhead Plate	t_1	.203	.203	.204	.202	.203
	t_2	.201	.202	.202	.204	.202
Bkd Left Stiff.	t_1	.153	.153	.153	.154	.153
	t_2	.153	.153	.154	.153	.153
Bkd Right Stiff.	t_1	.153	.153	.153	.152	.153
	t_2	.153	.153	.155	.151	.154



Side View

Deck/Bulkhead Element Long. Bow Distortion

NR - Not recorded

in Figure 6-5. When these tasks were completed, each specimen was ready for installation in the appropriate test setup.

6.4 TEST SETUPS AND FIXTURES

All tests on the deck/bulkhead elements were conducted by the Rohr Industries Engineering Test Laboratories located at the Chula Vista plant. The static tensile tests were conducted in the Mechanical Test Laboratory; the tensile fatigue tests, in the Structural Test Laboratory.

6.4.1 STATIC TENSILE TESTS -- The entire setup for conducting static tensile tests on the deck/bulkhead element specimens essentially duplicated the setup previously described in Section 5.4.1 for the stiffened panels. The only change required for the deck/bulkhead elements involved repositioning of the test machine upper crosshead to accommodate the increased specimen length. All other aspects of the setup including the test machine and autographic recorder, specimen grips and extensometer were unchanged from the stiffened panel setup. An overall view of the deck/bulkhead element static tensile test setup is shown in Figure 6-6.

6.4.2 TENSILE FATIGUE TESTS -- The complete setup for conducting tensile fatigue tests on the deck/bulkhead element specimens also essentially duplicated the setup for the stiffened panel fatigue tests previously described in Section 5.4.2. Again the only difference in setup involved repositioning the load frame upper cross member and hydraulic servo actuator to accommodate the greater length of the deck/bulkhead specimens. All other aspects of the test setup including the basic load frame, specimen grips, hydraulic system and electronic control system were unchanged from the stiffened panel tensile fatigue tests. All of the deck/bulkhead fatigue tests were performed under operator control using the function generator and counter system [illegible] was implemented for the latter part of the stiffened panel [illegible] test program. A view of the deck/bulkhead element specimen [illegible] loading frame for fatigue testing is shown in Figure 6-7.

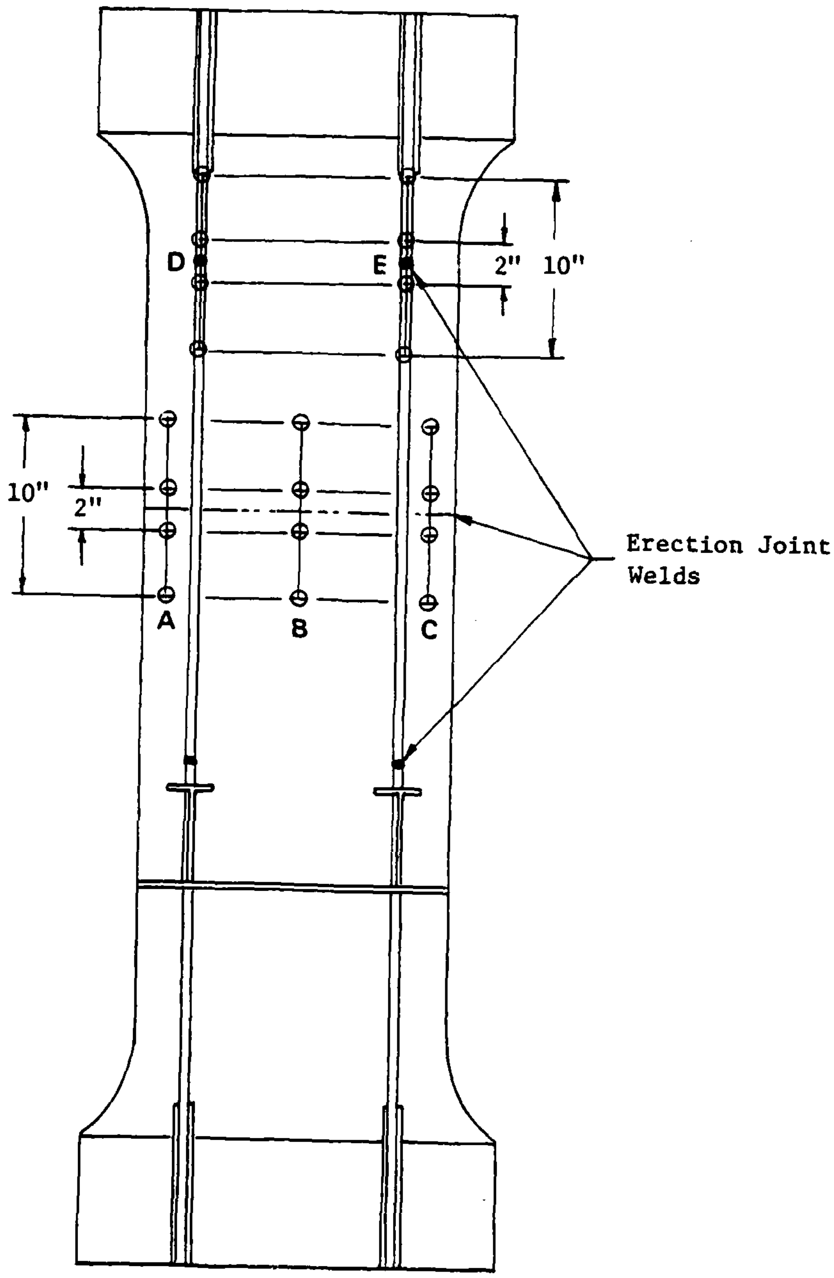


Figure 6-5. Scribed Gage Mark Locations on Deck/Bulkhead Element Static Tensile Test Specimens

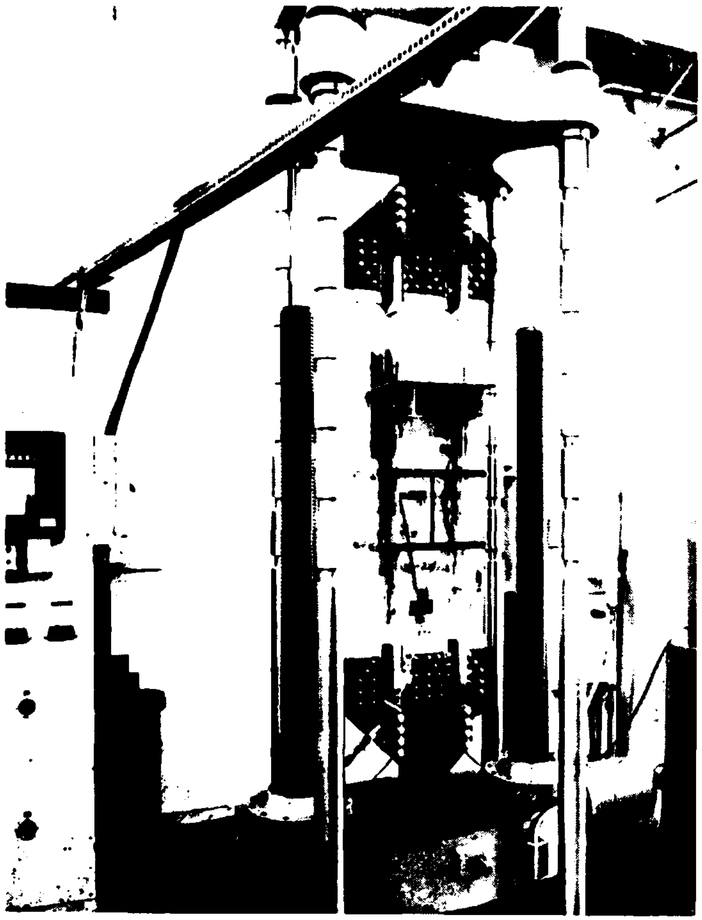


Figure 6-6. (790051-1) Deck/Bulkhead Element Static Tensile Test Setup in Tinius-Olsen Test Machine.

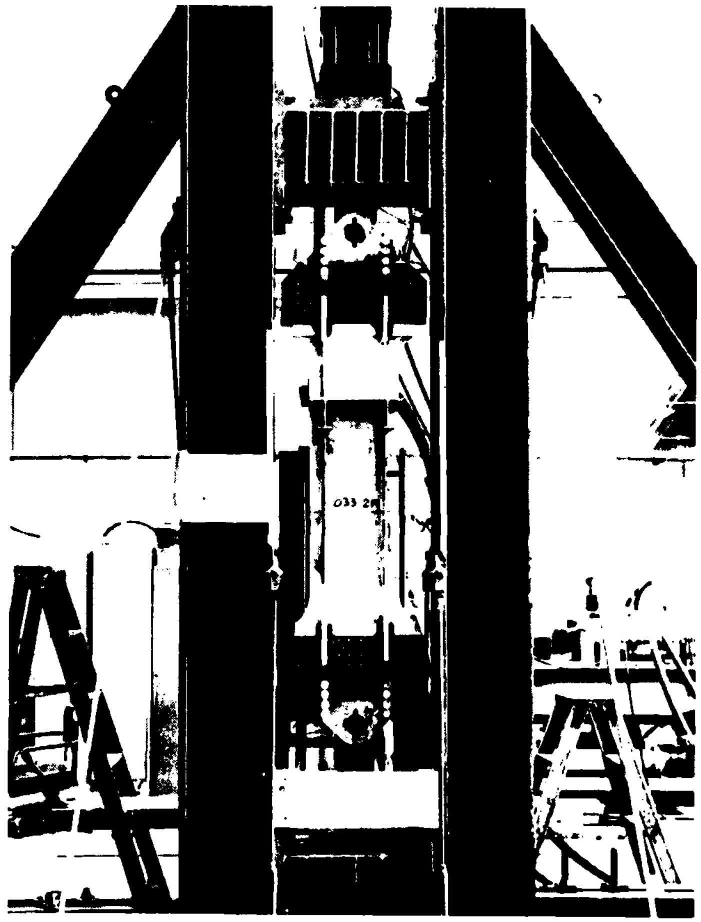


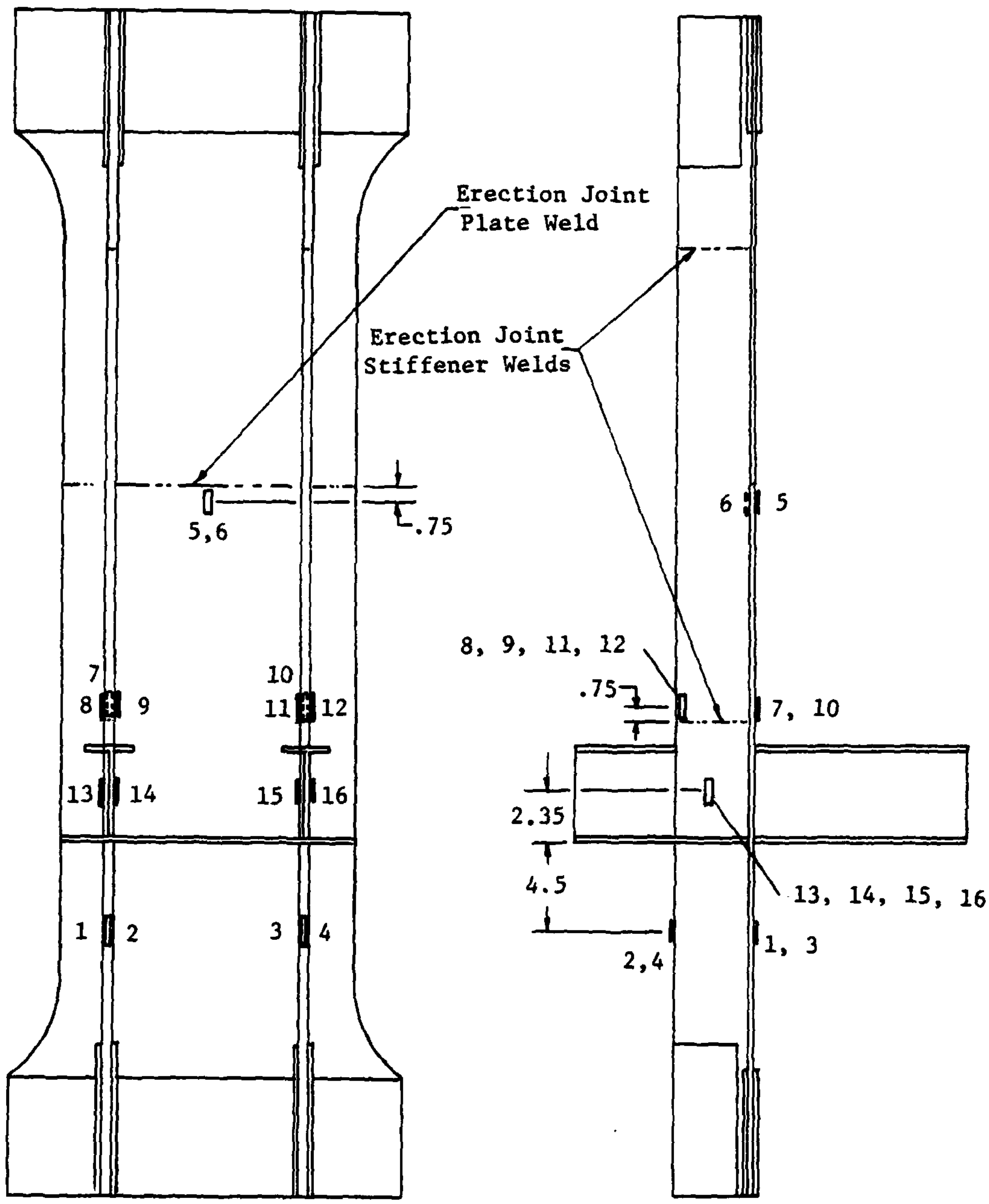
Figure 6-7. (790955-1) Deck/Bulkhead Element Setup for Tensile Fatigue Tests

6.5 INSTRUMENTATION AND DATA ACQUISITION EQUIPMENT

The Rohr Industries Test Laboratory Instrumentation Group was responsible for the installation of strain gages and the implementation, checkout and calibration of all equipment used in the acquisition of test data and the generation of fatigue loads during the course of deck/bulkhead element testing. All instrumentation was subject to the laboratory's quality assurance provisions instituted to preserve data precision and accuracy including National Bureau of Standards traceability. Calibration systems were in conformance with MIL-C-45662A, Reference 14. All instrumentation used during the deck/bulkhead element tests displayed evidence of current calibration certification. Detailed descriptions of the instrumentation and data acquisition equipment utilized for the deck/bulkhead element tensile static and fatigue tests are presented in the paragraphs below.

6.5.1 STATIC TENSILE TEST INSTRUMENTATION -- Standard commercial uniaxial strain gages, Micro-Measurements Type EA-13-250BG-120W, were bonded to each deck/bulkhead element specimen scheduled for static testing using Rohr Industries Test Laboratory standard installation procedures. Characteristics of these strain gages included 1/4 inch gage length, 120 ohm basic resistance, temperature balanced for use on aluminum and a rated static strain rage of ± 0.005. A pattern of 16 strain gages was installed on each test specimen at the locations and orientations depicted in Figure 6-8. In accordance with the Reference 2 test plan, these locations were intended to verify the uniformity of the applied loading and determine the strain distributions at the intersection and erection joints in each specimen.

All strain gages were connected to a B & F Instruments Model 256 digital data acquisition system with 260 channel capacity. This data system contained the necessary signal conditioning to output the data directly in engineering units, i.e., strain in micro-inches per inch. Upon command, the data system produced a paper tape print-out of the date, time of day, and all reduced data readings at the rate of 20 channels



Note: All dimensions shown in inches.

Figure 6-8. Strain Gage Identifications, Locations and Orientations for Deck/Bulkhead Element Static Tensile Test Specimens.

per second. Rated range of the B & F data system was $\pm$ 10,000 units on each channel with a rated accuracy of $\pm$ 10 units.

Prior to the start of testing, the basic B & F data system was calibrated against voltage standard by the Rohr Industries Test Laboratory Instrumentation Group. The voltage standard used, EDC direct current voltage calibrator Model 2902, Serial No. 6447, showed evidence of current calibration by National Astro Laboratories against National Bureau of Standards calibrated standard. Prior to the start of each test condition, all strain gages were end-to-end calibrated with the assigned data system channels and connecting cables to the manufacturer's certified gage factor furnished with the strain gages.

In addition to the above instrumentation, a Tinius-Olsen LVDT (Linear Variable Displacement Transformer) Electronic Extensometer, Model No. S-4002AB, Serial No. 126524, mounted in a Rohr Industries fabricated 10-inch gage length extensometer frame, was clamped to each deck/bulkhead element specimen for the first phase of static testing. A previous calibration of the basic extensometer by the manufacturer remained current through the pertenent test period. The signal from the extensometer was recorded on the Tinius-Olsen Universal Test Machine autographic recorder.

6.5.2 TENSILE FATIGUE TEST INSTRUMENTATION — Standard commercial uniaxial strain gages were bonded to each deck/bulkhead element fatigue test specimen using Rohr Industries Test Laboratory standard installation procedures. In general, Micro-Measurements Type EA-13-250BG-120W strain gages were utilized. Principal characteristics of these gages included 1/4 inch gage length, 120 ohm basic resistance, temperature balanced for use on aluminum, and a fatigue endurance rating of $\pm$ 0.0015 strain for 1,000,000 cycles. Where dictated by space limitations, Micro-Measurements Type EA-13-125AD-120 strain gages were employed. Principal characteristics of these gages were the same as described above except the gage length was 1/8 inch. A pattern

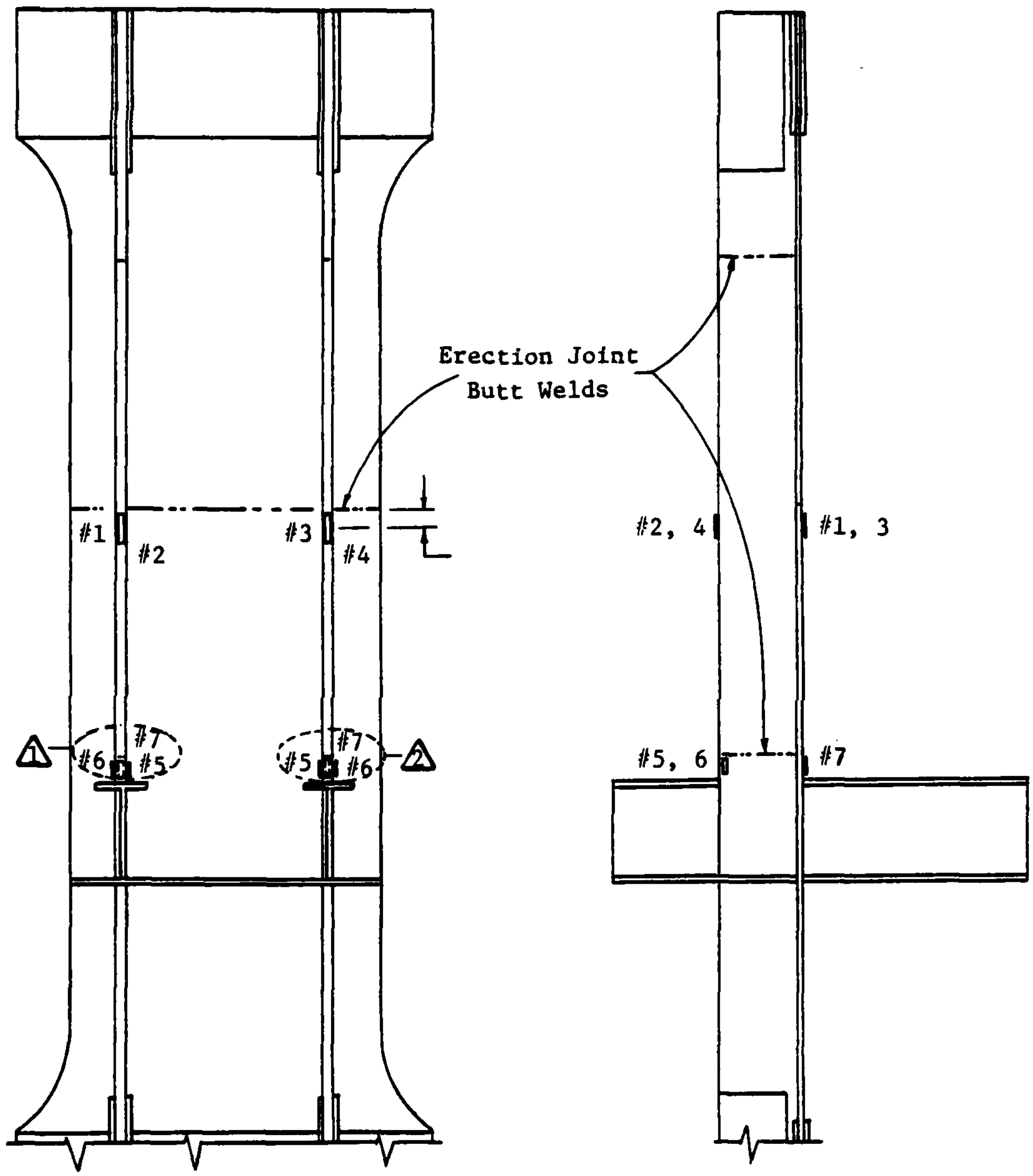
of 7 strain gages was installed on each fatigue test specimen at the locations and orientations depicted in Figure 6-9. Four of these locations were in accordance with the Reference 2 test plan to verify the uniformity of applied loading. The remaining locations were added to measure the stress magnification at the most critical location determined from the specimen pretest distortion measurements.

The fatigue test setup load cell and 6 of the 7 strain gages installed on each specimen were connected to a Visicorder Model 1508A oscillograph for recording during the fatigue testing. Validyne strain gage amplifiers were employed for signal conditioning and an EDC direct current voltage calibrator was utilized for strain gage calibration prior to each test condition. For improved reading precision, the 6 specimen strain gages and the load cell were individually connected in sequence to a Dana digital voltmeter during the static load strain survey conducted on each specimen prior to the start of fatigue testing. The seventh specimen strain gage was read on a standard Budd strain indicator during the static strain survey.

Prior to the start of any testing, the oscillograph active channels were individually calibrated using EDC direct current voltage calibrator, Model 2902, Serial No. 6447. This instrument bore evidence of current calibration by National Astro Laboratories against National Bureau Standards calibrated standard. Prior to the start of each test condition and periodically during testing, all active strain gages were end-to-end calibrated with the assigned signal conditioning/oscillograph channels and connecting cables to the manufacturer's certified gage factors furnished with the strain gages.

6.6. TEST PROCEDURES

Since the deck/bulkhead element test specimens contained two areas of interest, i.e., the bulkhead intersection area and the deck erection joint area, two phases of testing were conducted on each specimen. Initial testing was conducted to determine the first or most critical



Notes: 1 For Specimen No. TT802033-1-F1 only.

2 For Specimens No. TT802033-1-F2 and -F3 only.

3. All gages were Micro-Measurements Type EA-13-250BG-120W except gages no. 5 and 6 on Specimen No. TT802033-1-F2 were Micro-Measurements Type EA-13-125AD-120.

Figure 6-9. Strain Gage Identifications, Locations and Orientations for Deck/Bulkhead Element Tensile Fatigue Test Specimens.

area of failure. Repairs were then made and the second phase of testing was performed in an attempt to establish the next most critical failure mode.

Static tensile testing was conducted on two of the five deck/bulkhead specimen replicates, and tensile fatigue tests were conducted on the remaining three replicates. The detail procedures employed for these tests are described below.

6.6.1 STATIC TENSILE TESTS -- In preparation for the initial phase of static testing, the partially disassembled specimen end grip assemblies were installed and aligned in the Tinius-Olsen Universal Test Machine. Installation of the first strain-gaged deck/bulkhead element specimen in the grips was then accomplished. The extensometer assembly was next mounted to the test specimen centered about the deck plate butt weld and connected to the test machine autographic recorder which was adjusted to a zero reading. The strain gage leads were connected to the data acquisition system, and each channel was wet to a zero reading, balanced, and end-to-end calibrated to read directly in engineering units of strain. "Layout Blue" spray lacquer was lightly applied to all of the critical specimen welds to function as a "brittle coating" and accentuate areas of initial deformation and yielding.

Immediately prior to the start of testing, all strain gage channels were re-adjusted, if required, to a zero reading and the initial zero load data was recorded. Strain gage resistance calibration data was also recorded. Loading was then applied to the specimen at the rate of 150,000 pounds per minute with momentary halts at each 25,000 pound increment to record the strain gage data. The specimen was carefully monitored visually, and after initial yielding became visible, the strain gage data was recorded at each 10,000 pound increment of increasing load. Loading was immediately halted when "incipient failure" became evident, i.e., visible cracking prior to gross fracture. The applied load was then released to zero, post-test strain readings were

recorded, and the specimen was removed from the test setup. Percentage elongation measurements were obtained and photographs were taken to document all incipient failure indications. The specimen was then submitted to RMI Production for repair and reinforcement of the failure areas.

The initial phase of static testing on the second deck/bulkhead element specimen was performed in the same manner as described above.

After both deck/bulkhead static test specimens had completed the initial phase of testing, all butt welds were radiographically examined for evidence of cracking. All visually and radiographically detected cracks were ground out and weld repaired. Radiographs were again taken of the repair welded areas to ascertain acceptable repair quality. All stiffener butt welds, whether containing repairs or not, were next ground flush and aluminum doubler plates were fillet welded in place across each such joint on both sides of the stiffener. A typical specimen after these repairs were completed is shown in Figure 6-10.

For the second phase of static tensile testing, procedures were the same for both specimens. Each repaired/reinforced specimen was first installed in the grips, and the "Layout Blue" lacquer was sprayed on the critical joint areas. No strain gage or extensometer instrumentation was employed for these tests. Loading was then applied at a rate of 150,000 pounds per minute and continued uninterrupted until specimen fracture occurred. Loading was then released, the specimen removed from the setup, and photographs were taken to document the failure mode.

6.6.2 TENSILE FATIGUE TESTS -- The partially disassembled specimen end grip assemblies were first installed in the fatigue test setup load frame. For each test, the selected strain-gaged deck/bulkhead element fatigue test specimen was properly installed in the grip assemblies. Each specimen strain gage was then connected to read on both the oscillograph recorder and a digital voltmeter. Each channel was balanced and end-to-end calibrated to read directly in units of strain.

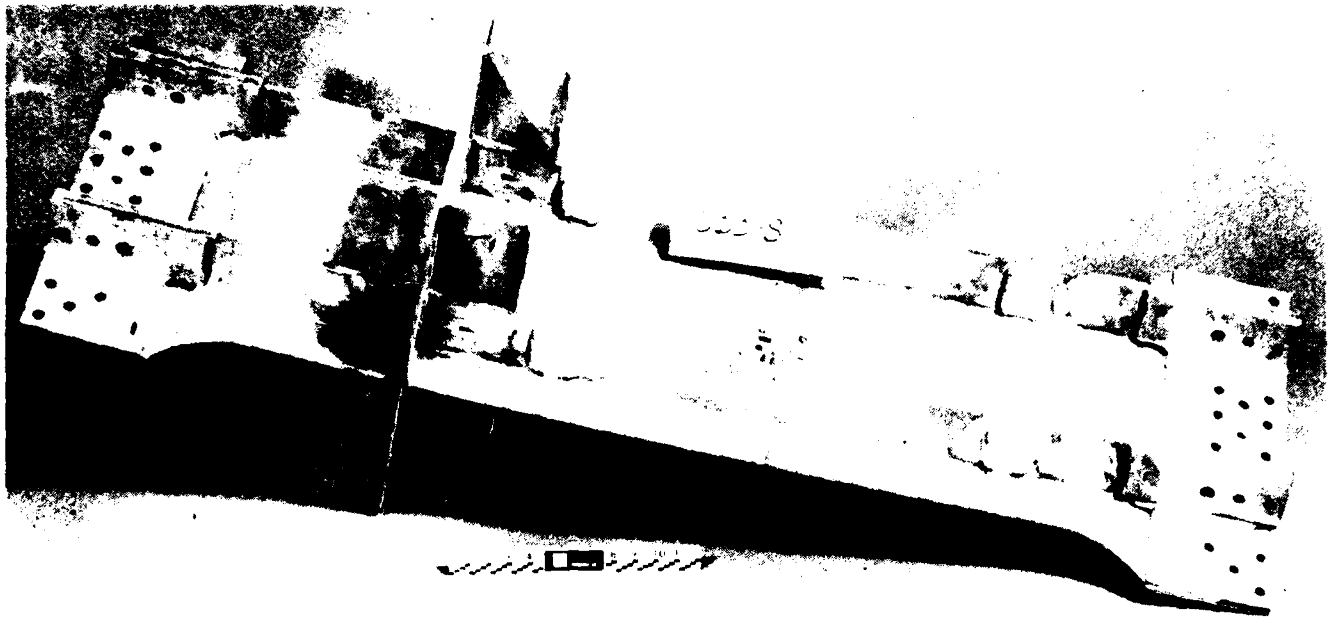


Figure 6-10. (790779-15) Typical Deck/Bulkhead Element Static Test Specimen After Stiffener Butt Weld Repair and Reinforcement.

Due to the presence of longitudinal bowing distortion in each deck/bulkhead specimen exceeding the specified limit, a static load strain survey was performed on each specimen prior to the fatigue test. This survey was conducted to document the specimen strain distribution and the strain magnification factor due to the distortion bending influence at each strain gage location. Static tension loading was applied in small increments of nominal tensile stress, and all strain gage readings were recorded at each increment. When the onset of permanent strain was detected at the most critical strain gage, the corresponding applied load or a reduced increment was selected as the maximum cyclic load for the fatigue test.

All fatigue testing was conducted at a stress ratio (R) of 0.1. Fatigue load cycling was initiated at a slow rate and slowly increased to a rate slightly below that where distortion became visible in an oscilloscope trace of the load cycling curve. Continuous oscillograph recordings of the strain gages were made during the first increments of testing. As testing progressed, only biref oscillograph recordings were made at approximately 5,000 cycle intervals and whenever deemed useful by the test operator.

In general, the fatigue testing was interrupted every 10,000 or 20,000 cycles to perform close visual inspection of the specimen using a hand held light and magnifying glass as required. These inspections were performed with the maximum cyclic load maintained on the specimen to enhance the visibility of any cracks. Penetrant inspections were utilized for any questionable areas. Fatigue test cycling and inspections were continued in this manner until a crack was detected. When a crack developed in the near vicinity of one or more strain gages, shafts in the oscillograph traces from these gages often provided an indication of internal damage prior to visible formation of the crack on the specimen surface.

Once a crack was visually detected, the extent of the crack was recorded and test cycling was continued with inspections performed at 5000 cycle intervals or less. Crack propagation data was recorded at each inspection period. Since it was an objective of the fatigue test to demonstrate the two most critical failure modes on the deck/bulkhead element specimens, stop drilling operations and or weld repairs were performed on the initial cracks appearing in each specimen. The above procedures were followed until complete failure of the specimen by the second mode of failure was imminent or actually occurred. Photographs of the specimens were taken during testing and after completion of testing to document crack appearance, crack stop drilling techniques, weld repairs and final specimen failure.

Because of the degraded fatigue performance from the first two deck/bulkhead element replicates tested, a decision was made to rework the critical area on the third specimen (TT802033-1-F2) prior to testing. Before rework was started, the critical area on each side of the specimen where the bulkhead tee stiffener butt joins the free edge of the flatbar deck stiffener was radiographically examined. Indications of weld porosity, lack of penetration, slag and linear porosity were evident with the majority of defects located at the free end of each joint. The defective area in both joints was reworked by gouging out approximately 1/4 inch of weld from the free end of the joint and reworking with the Gas Tungsten Arc process. These welds were deposited to a smooth contour with no subsequent contour smoothing or peening. Radiographs taken after the weld rework was completed revealed acceptable weld quality.

6.7 TEST RESULTS

Results from the tensile static and fatigue tests conducted on the deck/bulkhead element specimens are presented below. Additional detailed data recorded during these tests are included in Appendix F for reference.

6.7.1 STATIC TENSILE TEST RESULTS -- Results from both the initial and the final phases of static tensile tests on the two bulkhead/element specimen replicates are summarized in Table 6-2. The 10 inch gage length yield strengths obtained from both replicates were directly comparable to the yield strengths obtained from the stiffened panel tests (Reference Table 5-4). The average deck/bulkhead yield strength was equal to the minimum yield stress of the basic 5456-H116 material and was approximately 27 percent higher than the 3KSES design allowable yield stress (26 ksi) for welded material.

By contrast, the critical mode ultimate tensile strengths obtained from both deck/bulkhead element replicates fell from 6 to 8 percent below the 3KSES minimum design requirements. The deck/bulkhead ultimate strength levels were also significantly below the corresponding values obtained from the stiffened panel static tensile tests. (Reference Table 5-4). These results were attributed primarily to sub-standard welding quality at the base of the stiffener butt welds combined with the degrading influence of the larger longitudinal bowing distortions present in the deck/bulkhead specimens.

The autographically recorded load-strain plots and complete tabulations of the strain gage data recorded during the initial phase of static tensile testing on both deck/bulkhead element replicates are contained in Section 1 of Appendix F. Plots of the strain data recorded for one replicate are presented in Figure 6-11. This figure compares to those for the stiffened panels presented in Section 5.7 of this report and in the H-5 Advanced Development Program reports (References 5 and 6). From Figure 6-11, it is evident that various strain gage locations detected the onset of plastic strain at a specimen average tensile stress of approximately 16 ksi. These locations reflected the influence of the specimen distortions including longitudinal bowing and butt joint mismatch as well as the effects of localized reduced yield strengths in welding heat affected zones.

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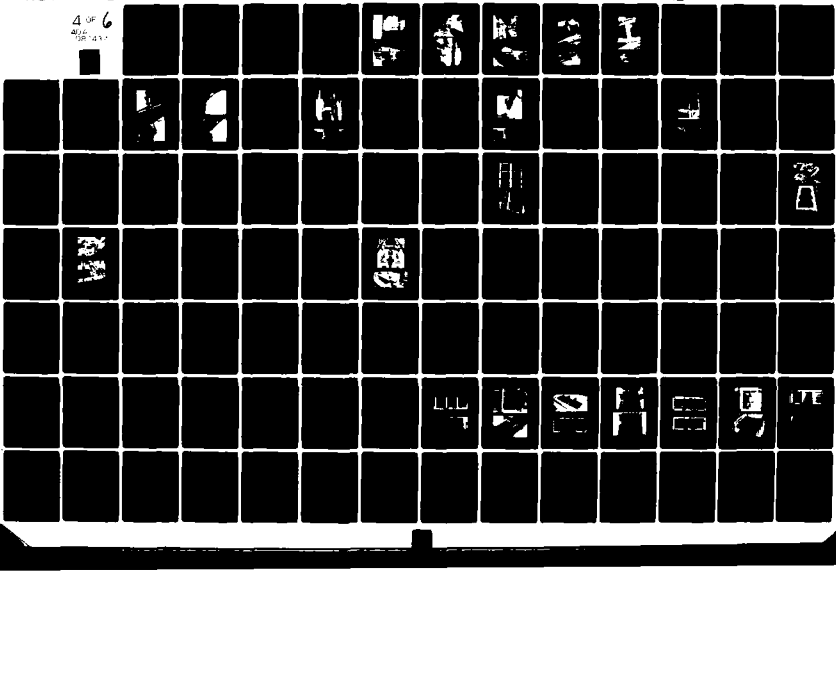

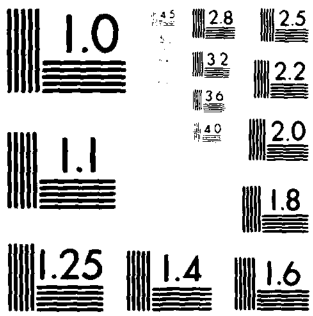

MICROCOPY RESOLUTION TEST CHART

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Table 6-2. Deck/Bulkhead Element Static Tension Test Results.

Specimen Identification	Cross Section Area (in^2)	Yield Strength) (10" Gage Length)		Ultimate Data (Initial Test Phase)			Percentage Elongation			Repaired Specimen Failure Data (2nd Test Phase)		
		Load (kips)	Stress (ksi)	Load (kips)	Stress (ksi)	Failure Mode	Loc. △1	2" G.L.	10" G.L.	Load (kips)	Stress (kips)	Failure Mode
TT802033-1-S1	6.255	209.5	33.5	230.5	36.9	△2	A	1.8	0.5	253.0	40.4	△4
							B	2.2	0.6			
							C	1.6	0.3			
							D	2.5	0.6			
							E	3.2	0.7			
TT802033-1S2	6.248	202.5	32.4	235.0	37.6	△3	A	1.8	0.8	267.5	42.8	△5
							B	3.1	0.8			
							C	1.8	0.7			
							D	3.5	0.9			
							E	4.3	0.9			
Average			33.0		37.2			2.6			41.6	
3KSES Design Allowables			26.0		40.0							

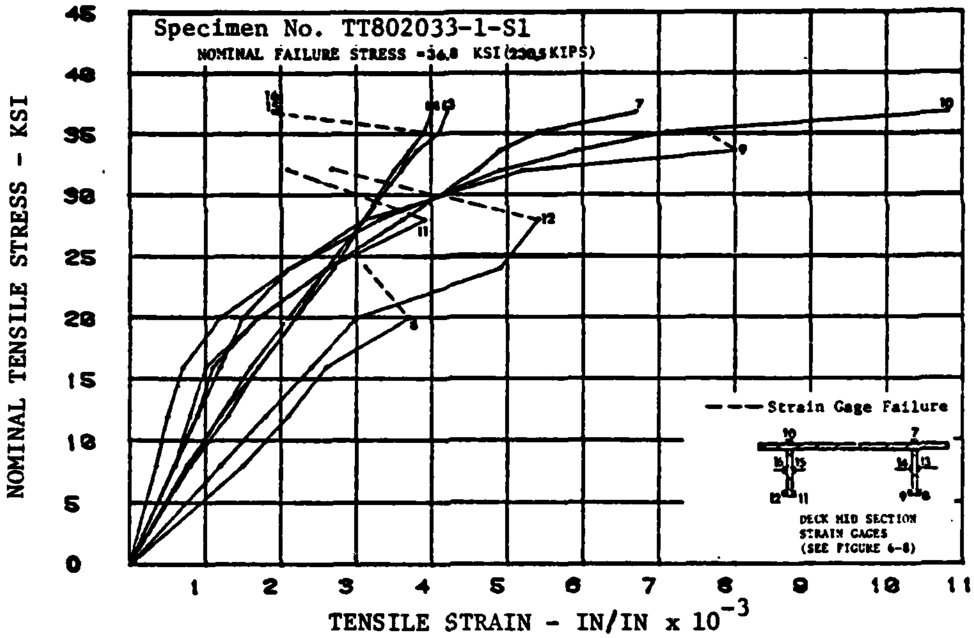
NOTES: △1 Locations as shown in Figure 6-5.

△2 Fracture at one stiffener butt weld nearest bulkhead intersection; visible cracking in three remaining stiffener butt welds.

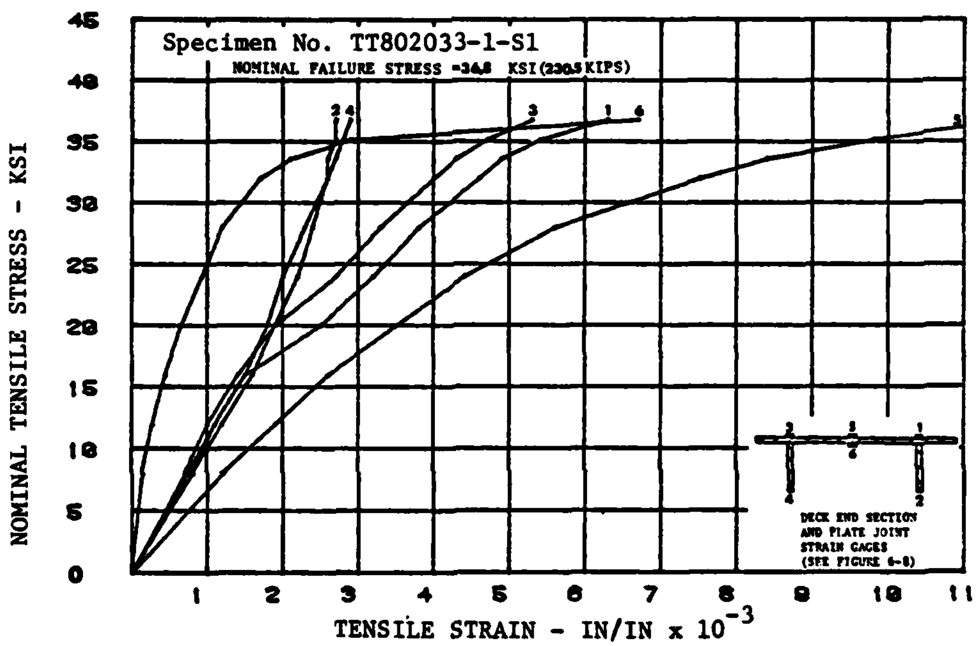
△3 Visible cracking in both stiffener butt welds nearest bulkhead intersection.

△4 Deck panel fracture initiating at stiffener butt weld.

△5 Deck panel parent metal fracture initiating at bulkhead stiffener to deck stiffener free edges intersection point.



a) Strain Gages at Deck Mid Section Near Bulkhead Intersection.



b) Strain Gages at Deck End Section and Deck Plate Butt Joint.

Figure 6-11. Typical Stress-Strain Curves from Deck/Bulkhead Element Static Tensile Test.

The influence of the specimen distortions is illustrated by the stress envelopes plotted in Figure 6-12. Each stress envelope compares the maximum and minimum local stresses measured at or near the specimen mid-section to the average applied stress for average stresses below the proportional limit. These envelopes illustrate the difference in stress distribution due to localized and overall bending. The specimen overall bending primarily resulted from angular distortion at each deck stiffener butt joint caused by unequal weld shrinkage. The increased length of the deck/bulkhead specimens compared to the stiffened panel specimens, coupled with the additional welding at the bulkhead penetration, served to accentuate the overall bending influence. Localized bending primarily resulted from the intentional mismatch at the deck plate and stiffener butt joints.

Photographs of the two deck/bulkhead element specimens taken after the initial phase of static tensile testing are presented in Figures 6-13 and 6-14. Typical failure details are also shown.

The initial static test of specimen replicate-S2 was terminated when cracks initiated at three of the four stiffneer butt joints as shown in Figures 6-14(a) and (b).

Ultimate tensile strengths obtained from the final static tests on the two weld-repaired and reinforced deck/bulkhead element specimens are included in Table 6-2 shown previously. Both specimens exhibited higher strength levels than previous and both exceeded the 3KSES ultimate tensile design allowable. Photographs of the failed specimens after the final static tests are shown in Figures 6-15 and 6-16. Failure in specimen replicate-S1 (Figure 6-15) again initiated in a stiffener butt joint. This mode of failure recurred since post-failure examination revealed that the reinforcing doublers at the failure site were mislocated to one side of the weld joint rather than centered across the joint. A second mode of failure was achieved in specimen replicate-S2. In this case, failure initiated at the sharp notch where the flange of the

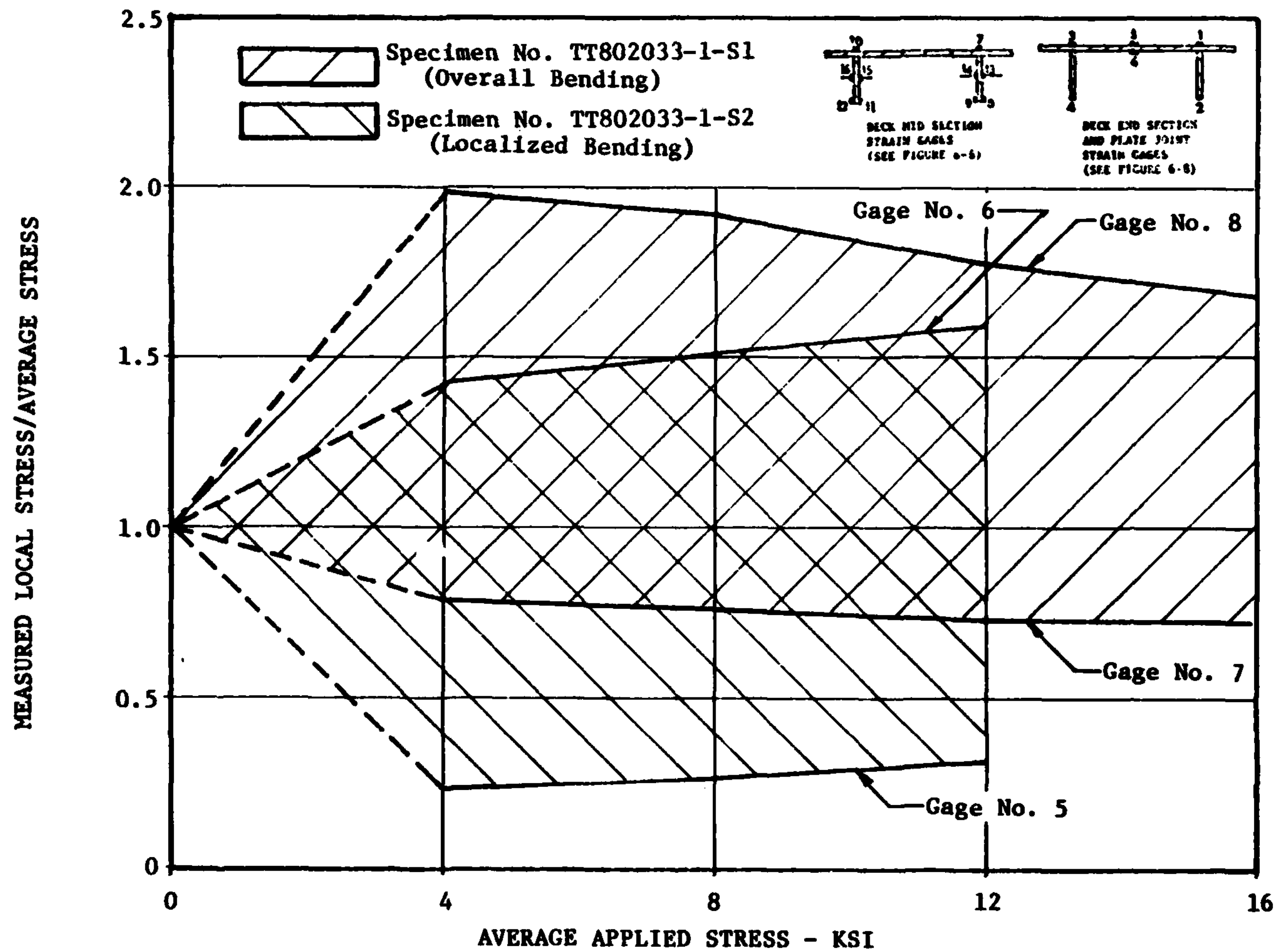
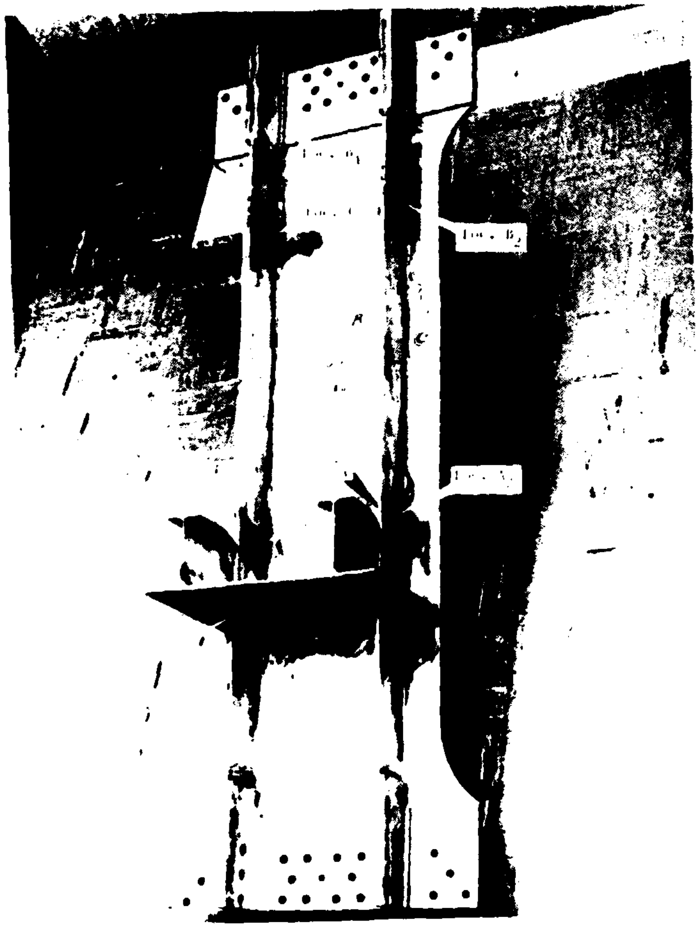


Figure 6-12. Maximum Local Stress Ratio Envelopes from Deck/Bulkhead Element Static Tensile Tests.



a) (79-58-8) Specimen Overall View Showing Location of Failures.

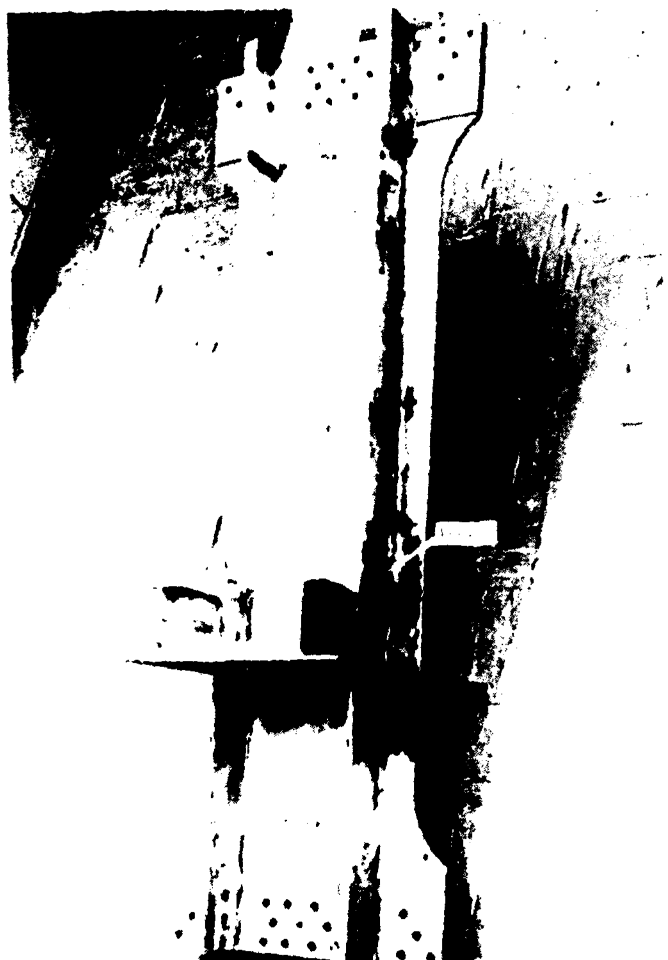
b) (79-58-5) Detail View of Stiffener Butt Weld Failure (at Location A_1).

Figure 6-13. Deck/Bulkhead Element No. TT802033-1-S1 After Initial Static Tensile Test. (Sheet 1 of 2)

c) (79-58-3) Typical Stiffener Butt Weld Crack Formation (Location B_2).

d) (79-58-7) Detail of Deck Stiffener to Bulkhead Plate Fillet Weld Crack at Location E.

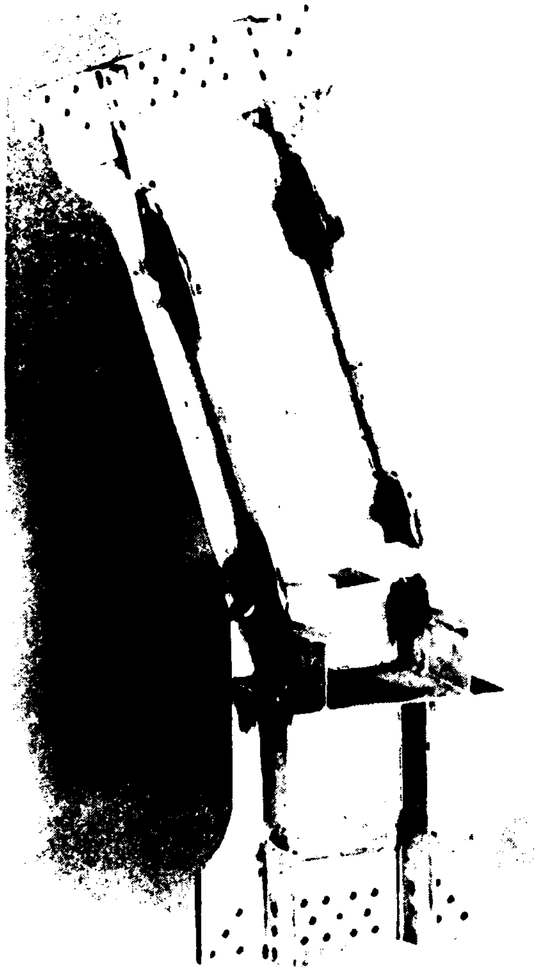
Figure 6-13. Deck/Bulkhead Element No. TT802033-1 S1 After Initial Statis Tensile Test. (Sheet 2 of 2)



a) (79-46-4) Specimen Overall View Showing Locations of Failures.

b) (79-46-3) Detail View of Typical Stiffener Butt Weld Crack Formation (Location A).

Figure 6-14. Deck/Bulkhead Element No. TT802033-1-S2 After Initial Static Tensile Test.



a) (790919-2) Specimen Overall View

b) (790919-3) Close-Up View of Fracture.

Figure 6-15. Deck/Bulkhead Element No. TT802033-1-S1 After Final Static Tensile Test to Failure.

a) (790919-1) Specimen Overall View

b) (790919-5) Close-Up View of Fracture Surface. (Failure initiated in right hand stiffener at intersection with lower right bulkhead tee stiffener sniped flange.)

Figure 6-16. Deck/Bulkhead Element No. TT802033-1-SZ After Final Static Tensile Test to Failure.

bulkhead tee stiffener butts the free edge of the deck flatbar stiffener as shown in Figure 6-16. With this mode of failure, the achieved ultimate tensile strength was up to 13 percent higher than the strength level associated with the more critical stiffener joint failure mode.

6.7.2 TENSILE FATIGUE TEST RESULTS — The peak stress magnification factors obtained from the strain survey static tests conducted on each deck/bulkhead fatigue specimen are presented in Figure 6-17. As shown, the peak magnification factors ranged from 1.6 up to 2.5 resulting in comparatively low nominal stress levels being selected for the maximum fatigue cycling loads to minimize strain hardening effects. Complete tabulations of all strain data obtained from the strain survey static tests are provided in Section 2 of Appendix F.

Results from the deck/bulkhead element specimen fatigue tests are shown graphically in Figure 6-18. Individual test data points and an S-N envelope are shown for each of the two defined specimen categories. Although the deck/bulkhead element specimens were originally fabricated as three replicates, degraded fatigue performance from the first two replicates resulted in a decision to rework the critical area on the third specimen prior to the start of fatigue testing. This rework was described in Section 6.6.2 above. Therefore, separate S-N envelopes are shown in Figure 6-18 for the element specimens as-produced and for the specimen reworked before testing.

The S-N envelopes shown in Figure 6-18 were defined by theoretically derived S-N curves drawn through the lowest and highest data points for each specimen type as previously described in Section 4.7.1.2. Only those data points representing crack initiation in the first, or most critical, mode of failure were utilized to establish the S-N envelopes. The initial crack appearing in each specimen was stop drilled and for weld repaired. Therefore, a second crack initiating at a different location on the specimen but following the identical mode of failure was also considered to be a valid data point reflecting normal scatter.

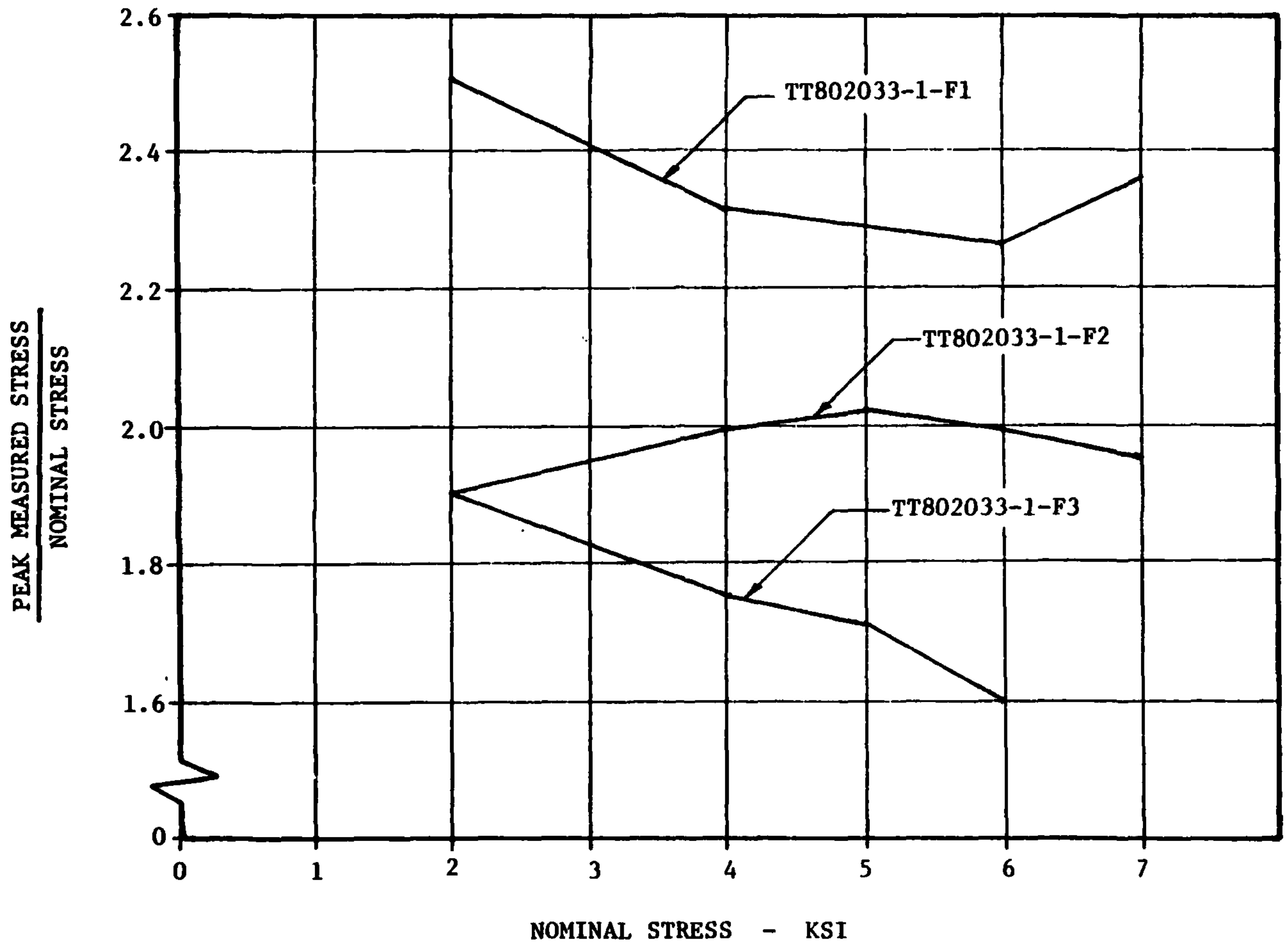


Figure 6-17. Measured Static Stress Magnification Factors for Deck/Bulkhead Fatigue Test Specimens.

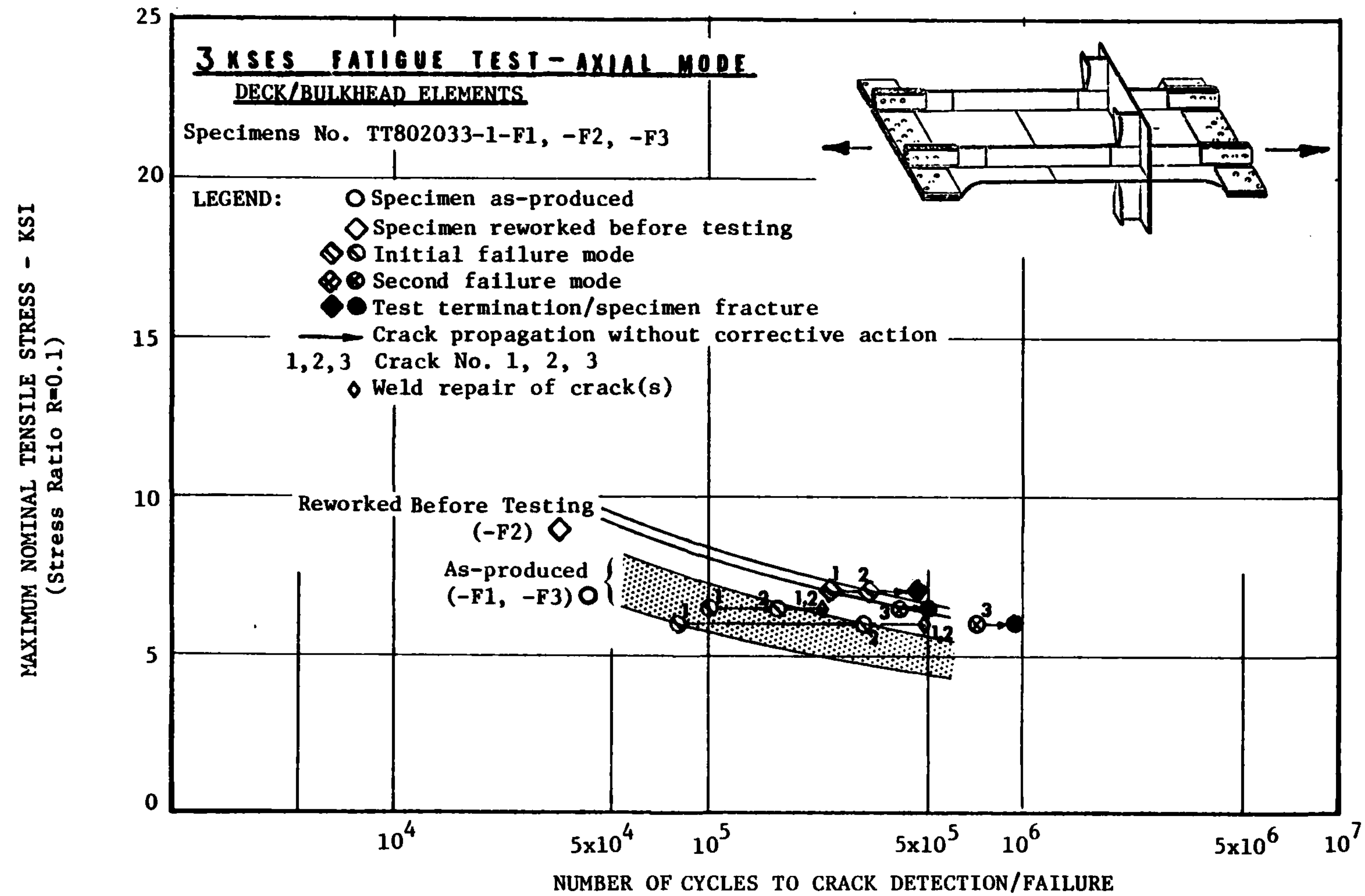


Figure 6-18. Deck/Bulkhead Element Tensile Fatigue Test Results.

This approach served to expand the fatigue data base from the very limited number of specimens.

In acquiring the maximum amount of data from each specimen, additional complexities and the possibility of failure interactions were introduced into the tests. Therefore, the significant results and events from the fatigue test conducted on each of the three-deck/bulkhead element specimens are summarized below in chronological form.

6.7.2.1 Fatigue Test Chronology-Specimen No. TT802033-1-F1 (As-Produced) -- Nominal Axial Stress Cyclic Range: 6.5 ksi to 0.65 ksi.

40,000 Cycles - Slight shift noted in data from two strain gages located in vicinity of subsequent fatigue crack; shift may signify initiation of fatigue damage.

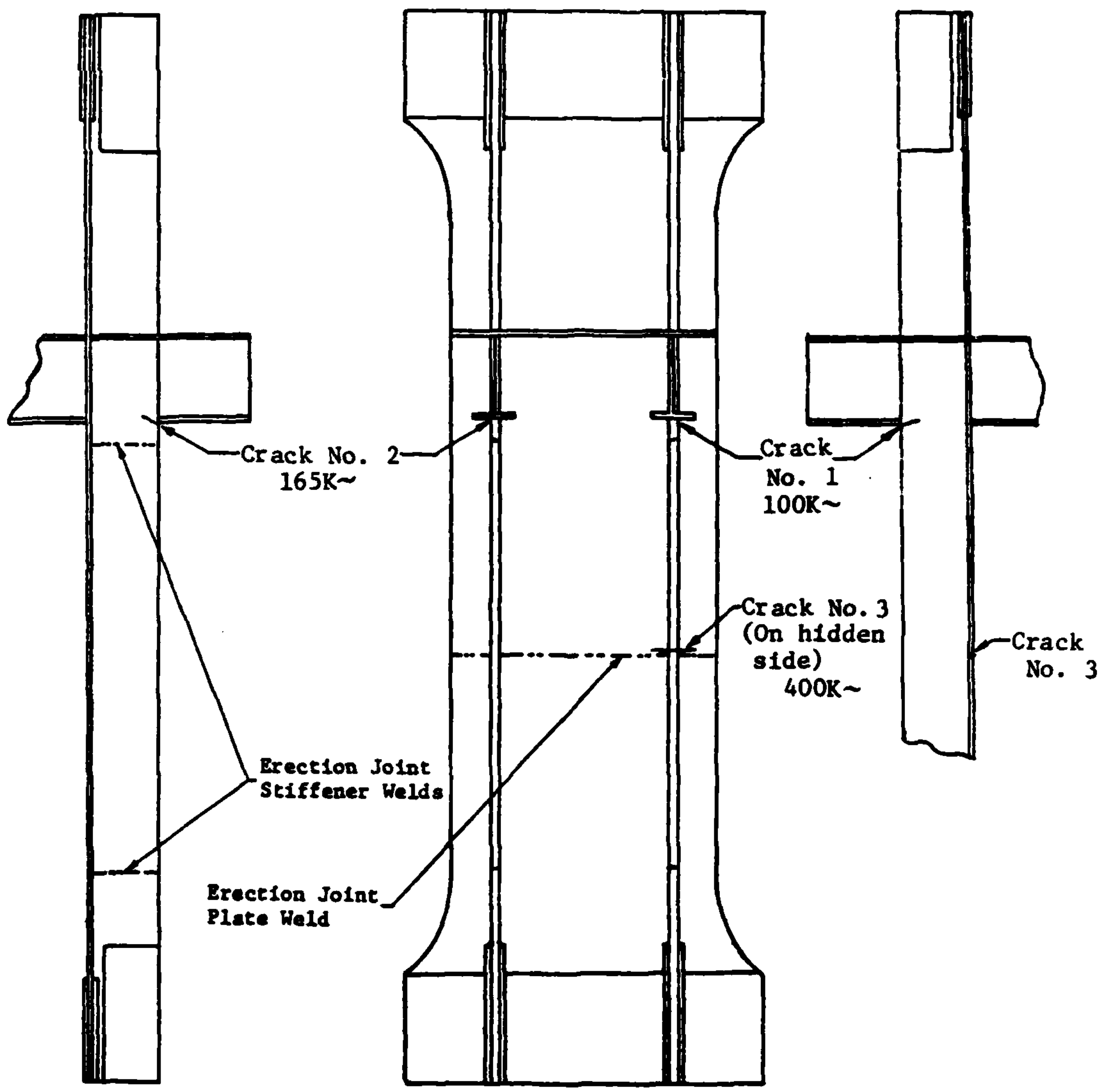
100,000 Cycles - Initial crack visually detected. This crack, identified as Crack No. 1 on Figure 6-19, initiated at the sharp corner formed by the bulkhead tee stiffener flange intersection with the free edge of the deck flatbar stiffener. A photograph of the crack is shown in Figure 6-20(a). Before test resumption, a 1/8 inch diameter hole was drilled through the crack leading edge in an attempt to arrest crack growth.

165,000 Cycles - Second crack visually detected. Identified as Crack No. 2 on Figure 6-19, this crack was essentially identical in nature to Crack No. 1.

170,000 Cycles - Enlarged stop hole on Crack No. 1 to 3/16 inch diameter.

175,000 Cycles - Enlarged stop hole on Crack No. 1 to 1/4 inch diameter; drilled stop hole on Crack No. 2.

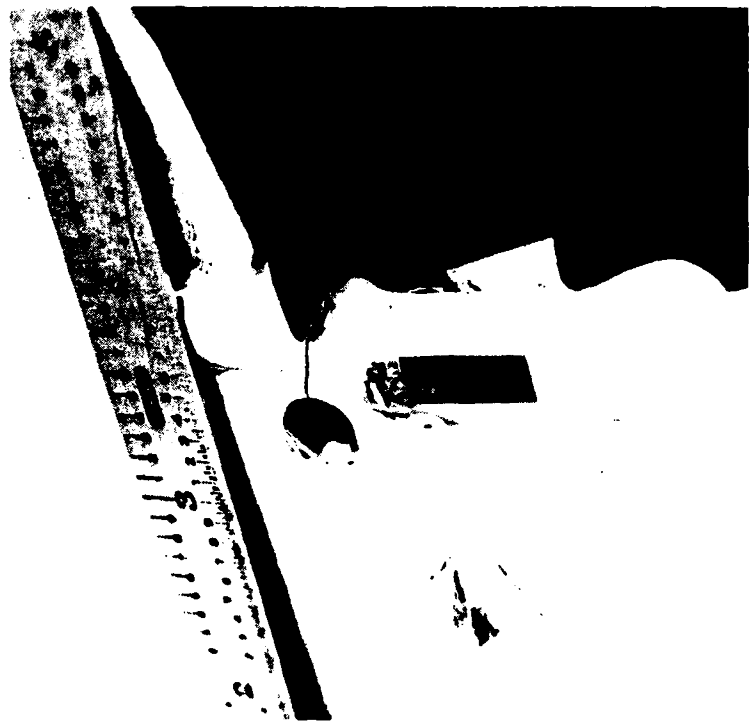
177,000 Cycles - Elongated stop hole on Crack No. 1 and enlarged stop hole on Crack No. 2; radiused corners and polished surfaces of stop holes.



NOTE: Crack visually detected at number of load cycles shown.

Figure 6-19. Fatigue Crack Pattern - Deck/Bulkhead Element Specimen No. TT803022-1-F1.

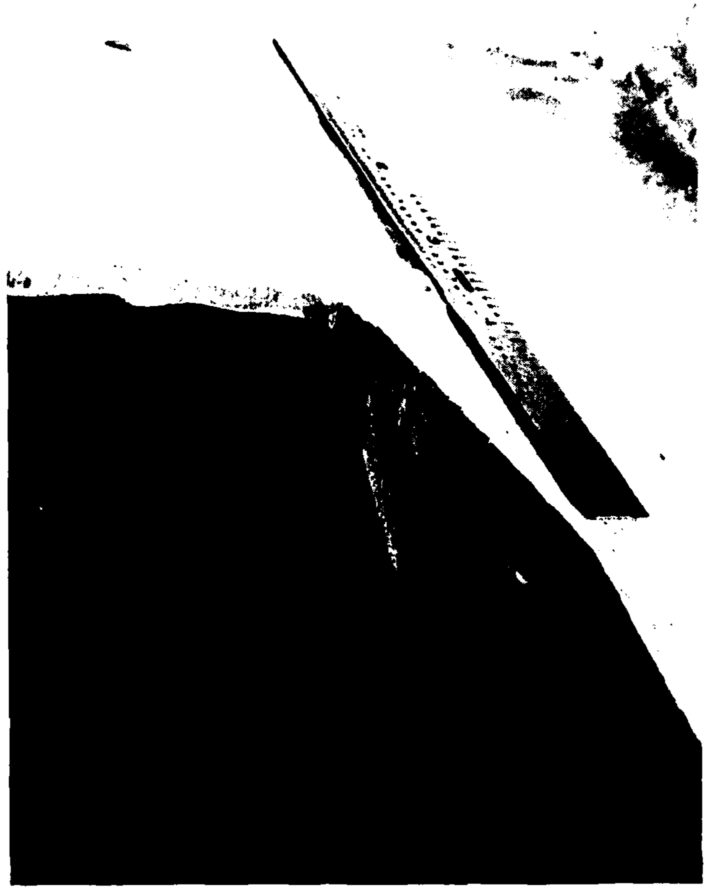
a) (790870-3) Crack No. 1 When Visually Detected at 100,000 Load Cycles.



b) (790871-1) Crack No. 1 Propagation Through Stop Hole at 226, 950 Load Cycles.

Figure 6-20. Initial Fatigue Crack Propogation and Repair in Deck/Bulkhead Element No. TT802033-1-F1. (Sheet 1 of 2)

c) (790875-2) Crack No. 1 Ground Out in Preparation for Repair Welding After Test Stoppage at 226,950 Load Cycles



d) (790875-4) Completed Weld Repair at Location of Crack No. 1

Figure 6-20. Initial Fatigue Crack Propogation and Repair in Deck/Bulkhead Element No. TT802033-1-F1. (Sheet 2 of 2)

226,952 Cycles - Test suspended for weld repairs after Crack No. 1 propagated through stop hole as shown in Figure 6-20(b). To effect repairs, the area around each crack and stop hole was first routed out as shown in Figure 6-20(c). Gas tungsten arc welding with a hand torch was then employed to fill the routed cavity and form a 1/4 inch minimum radius fillet to reduce the stress concentration at the original point of crack initiation. The weld repair area was blended to a smooth contour using a rotary file and small sanding discs followed by rotary brush peening to an 0.004 Almen A intensity. A photograph of the completed repair at the location of Crack No. 1 is presented in Figure 6-20(d). All of these reapirs were per-ormed with the specimen in the test setup.

400,000 Cycles - A new crack, constituting a second mode of failure, was visually detected. This crack, identified as Crack No. 3 on Figure 6-19, initiated along the toe of the deck plate butt weld on the side of the specimen opposite the flatbar stiffeners.

500,000 Cycles - Testing terminated with Crack No. 3 at 2.1 inches long. Photographs of specimen no. TT802033-1-F1 after the completion of testing, including a detail view of Crack No. 3, are shown in Figure 6-21.

6.7.2.2 Fatigue Test Chronology-Specimen No. TT802033-1-F3 (As-Produced) -- Nominal Axial Stress Cyclic Range: 6.0 ksi to 0.6 ksi.

50,000 Cycles - Shift noted in data from two strain gages located in vicinity of subsequent fatigue crack, possibly indicating early stage of fatigue damage.

a) (790982-3) Specimen Overall View

b) (790982-5) Close-Up View of Deck Plate Butt Weld Fatigue Crack. (Second failure mode)

Figure 6-21. Deck/Bulkhead Element No. TT802033-1-F1 After Completion of Tensile Fatigue Testing.

80,000 Cycles - Initial crack, identified as Crack No. 1 on Figure 6-22, visually detected. This crack initiated at the ship corner formed by the bulkhead tee stiffener flange intersection with the free edge of the deck flatbar stiffener.

270,000 Cycles - 1/4 inch diameter stop hole drilled at leading edge of Crack No. 1. Corners of hole were rounded and hole surfaces were polished.

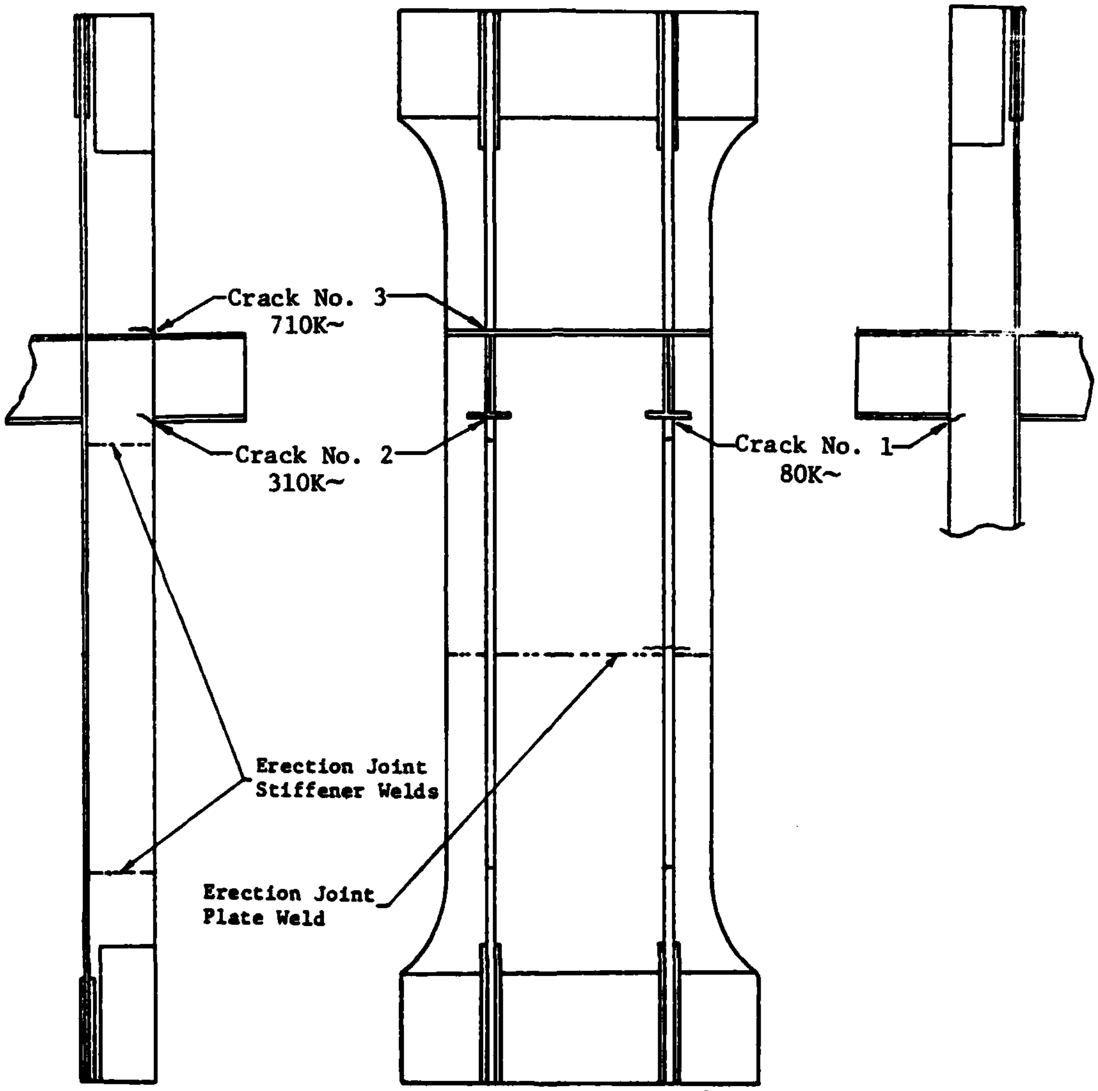
310,000 Cycles - Second crack visually detected. Identified as Crack No. 2 on Figure 6-22, this crack was essentially identical in nature with Crack No. 1.

330,000 Cycles - Crack No. 2 stop-drilled in same manner as Crack No. 1.

480,000 Cycles - Test suspended to remove specimen for weld repairs after Crack No. 1 propagated beyond stop hole. Weld repairs of Crack No. 1 and No. 2 were performed in same manner as described above for specimen dash no. -1-F1, except that peening was omitted and the -1-F3 specimen was optimally oriented for welding.

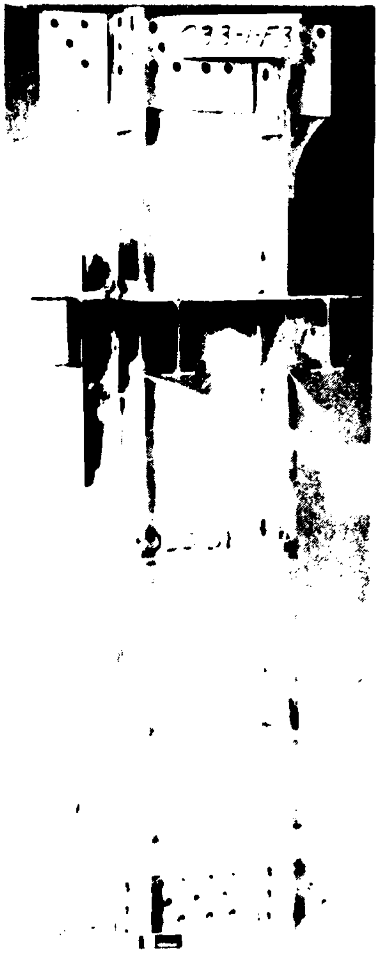
710,000 Cycles - A new crack, constituting a second mode of failure, visually detected. This crack, identified as Crack No. 3 in Figure 6-22, initiated at the toe of the fillet weld wrap around the free edge of a deck flatbar stiffener at its penetration through the bulkhead plate.

950,000 Cycles - Testing terminated with Crack No. 3 over 2 inches long and sudden fracture imminent. Photographs of specimen no. TT802033-1-F3 at the completion of testing, including a detail view of Crack No. 3, are presented in Figure 6-23.

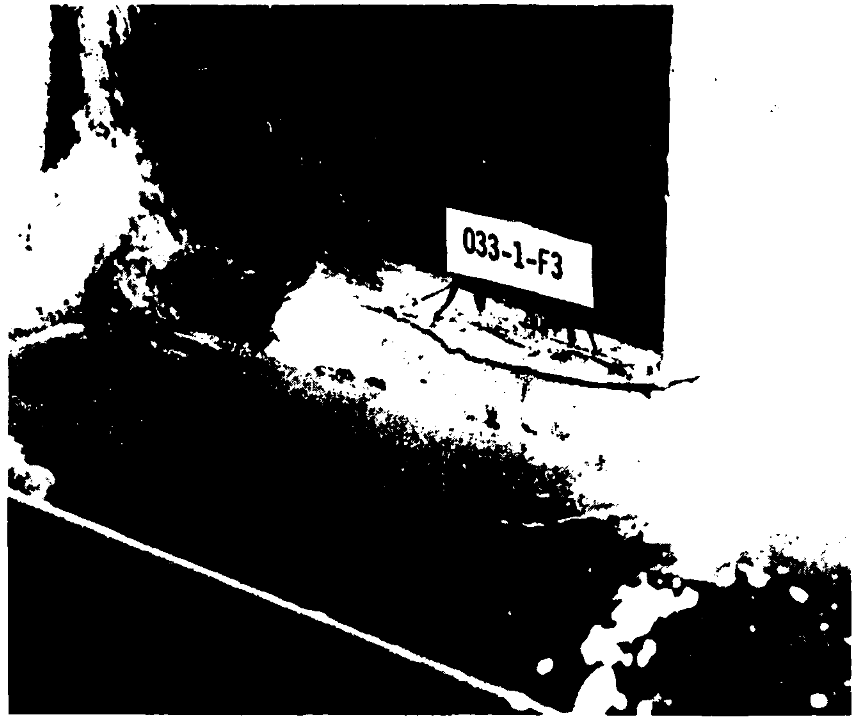


NOTE: Crack visually detected at number of load cycles shown.

Figure 6-22. Fatigue Crack Pattern - Deck/Bulkhead Element Specimen No. TT802033-1-F3.



a) (790982-2) Specimen Overall View



b) (790982-6) Close-Up View of Deck Stiffener Failure Initiating at Toe of Fillet Weld to Bulkhead Plate. (Second failure mode)

Figure 6-23. Deck/Bulkhead Element No. TT802033-1-F3 After Completion of Tensile Fatigue Testing.

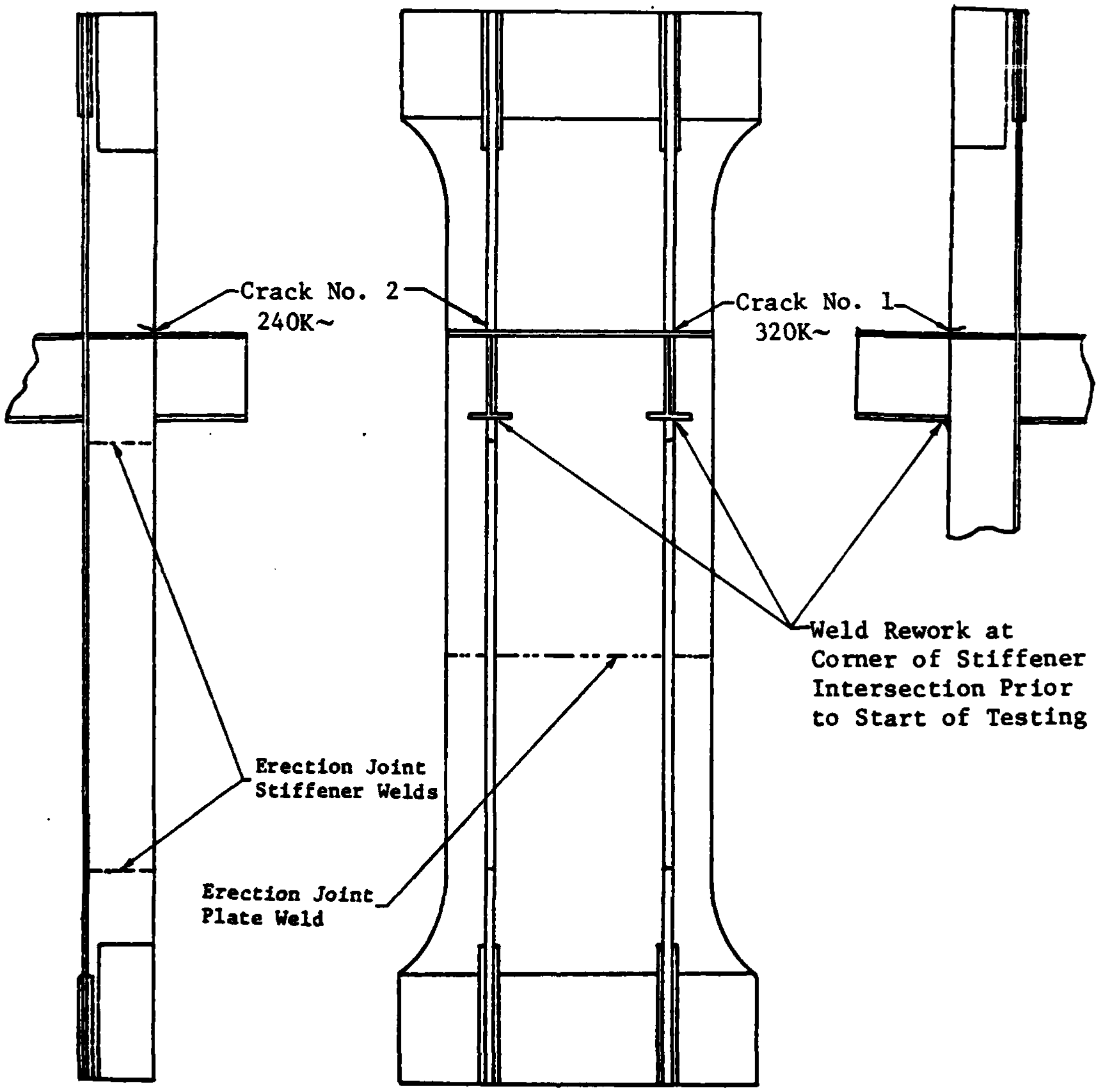
6.7.2.3 Fatigue Test Chronology-Specimen No. TT802033-1-F2 (Reworked Before Testing) -- Nominal Axial Stress Cyclic Range: 7.0 ksi to 0.7 ksi.

240,000 Cycles - Initial crack visually detected. This crack, identified as Crack No. 1 in Figure 6-24, initiated at the toe of the fillet weld wrap around the free edge of a deck flatbar stiffener at its penetration through the bulkhead plate. Test specimen was removed from the setup and weld reair of the crack was accomplished using the techniques previously described except that peening was again omitted.

320,000 Cycles - Second crack, identified as Crack No. 2 in Figure 6-24, visually detected. This crack was essentially identical in nature to Crack No. 1.

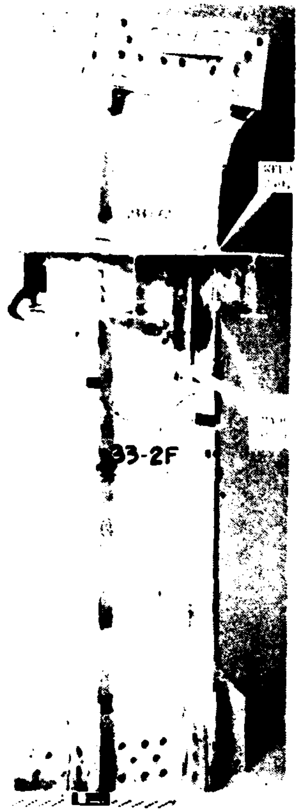
463,058 Cycles - Testing terminated by specimen fracture propagating from Crack No. 2. Photographs of this specimen at the completion of testing are presented in Figure 6-25.

6.7.2.4 Discussion and Correlation of Fatigue Test Results -- Without exception, the deck/bulkhead element fatigue tests demonstrated that the bulkhead intersection area was more critical to fatigue life than the deck erection joint. At the bulkhead intersection, the corner formed by the junction of the bulkhead tee stiffener flange to the free edge of the deck flatbar stiffener was shown to be by far the most fatigue critical point as designed and fabricated. Special efforts to rework this critical junction using improved welding techniques and post-weld blending yielded nearly 50 percent improvement in fatigue strength, i.e., from 4.4 to 6.4 ksi maximum nominal axial fatigue strength at 500,000 cycles endurance. With the reworked junction, failures initiated at the flatbar deck stiffener penetrations through the bulkhead plate. This failure mode was also the most prevalent mode



NOTE: Crack visually detected at number of load cycles shown.

Figure 6-24. Fatigue Crack Pattern - Deck/Bulkhead Element Specimen No. TT802033-1-F2.



a) (790982-1) Specimen Overall View

b) (790982-4) Close-Up View of Final Fatigue Failure. This second mode failure initiated at the toe of the fillet weld wrap on the free edge of the deck stiffener penetration through the bulkhead plate.

Figure 6-25. Deck/Bulkhead Element No. TT802033-1-F2 After Completion of Tensile Fatigue Testing.

which occured after repairs were made to the stiffener junction failures.

None of the fatigue cracks or fractures observed in the deck/bulkhead element test specimenx were attributed to welding imperfections. On all but one case (which was not the critical mode failure), the specimen fatigue fractures initiated at the edges of welds and propagated through the base match of the continuous deck stiffeners.

Comparisons of the deck/bulkhead element fatigue test results to those from the stiffened panel fatigue tests (described in Section 5) are presented in Figure 6-26. As shown, the fatigue performance of the deck/bulkhead elements fill below the performance of all stiffened panel specimens. The deck/bulkhead specimens which were tested in the as-produced condition fell significantly below the lower envolope boundary for the stiffened panels. Fatigue performance from the deck/bulkhead element which was reworked before testing to improve the critical stiffener intersection corner was essentially coincident with the lower boundary of the stiffened panel envelope. The lower boundary of the stiffened panel envelope was established by specimens with nominal offset mismatch at all deck erection joint butt joints; the erection point incorporated in each deck/bulkhead specimen was also fabricated with the same nominal mismatch at all butt joints.

As previously discussed, the deck/bulkhead element specimens were found to have significant longitudinal bowing distortions, the magnitudes of which were generally larger than the similar distortions found in the stiffened panels. In the deck/bulkhead element fatigue test specimens, the magnitudes of these longitudinal bowing distortions ranged from 88 to 246 percent of the specified maximum allowable limits. The degraded fatigue performance of the deck/bulkhead element specimens was partially atrributed to these distortions since all critical mode failures initiated at the free edge of the deck stiffener where the distortion-induced stress magnification was highest. Stress concentrations caused by abrupt hanges in cross-section at the locations of the two most

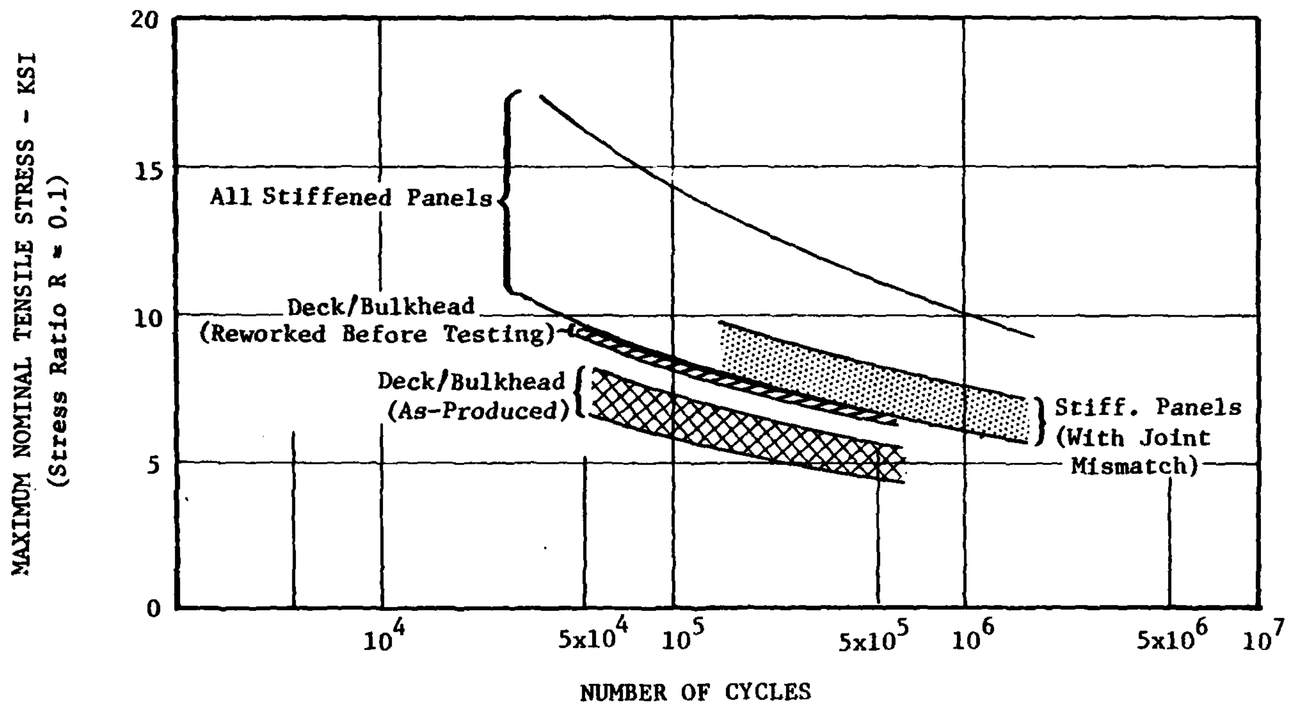


Figure 6-26. Comparative Fatigue Performance Between Stiffened Panel and Deck/Bulkhead Element Specimens.

critical failure modes were additional contributing factors to the degraded fatigue performance of the deck/bulkhead element specimens.

6.8 CONCLUSIONS

The test program described above has produced significant information on the strength characteristics of assemblies representing the intersection of transverse bulkheads with continuous deck structure. These assemblies were fabricated in a production environment with dimensional tolerances equal to or greater than established production standards. Conclusions relative to the static tension and tensile fatigue strength characteristics are summarized in the paragraphs below. The conclusions presented are based on the test results presented above and are applicable to the specific weldments and tests delineated herein.

6.8.1 STATIC TENSION -- The results from the static tensile tests validated the existing design allowable tensile yield and tensile ultimate strengths for continuous deck structure intersected by a transverse bulkhead. The results demonstrated that the 3KSES welded material design ultimate strength allowables are realistic for the bulkhead to deck intersection fabricated with practical tolerances. The results also demonstrated that the 3KSES design yield strength allowable is conservative for this type of structure.

Without exception, the critical mode of static test failure in the deck/bulkhead element specimsn was fracture of the deck stiffener butt welds at the deck erection joint located away from the bulkhead intersection area. Ultimate tensile strengths associated with this mode of failure were from 6 to 8 percent below the existing 3KSES design allowable tensile ultimate strength for welded structure. The primary factors influencing this result were substandard welding quality where the deck stiffener butt weld intersects the stiffener base fillet welds coupled with excessive longitudinal bowing distortions. Although the deck/bulkhead test procedures precluded detailed post-failure inspection of the area in question, the conclusion of sub-

standard welding quality is based on the fact that all of the stiffened panel specimens containing erection joints met or exceeded the 3KSES design allowable tensile strength.

With repairs and reinforcements added to preclude failure at the deck stiffener butt joints, the bulkhead intersection area became the next most critical mode of static tensile failure. The origin of failure was the sharp corner where the flange of the bulkhead tee stiffener interesects the free edge of the deck flatbar stiffener. However, the ultimate tensile strength associated with this mode of failure exceeded the 3KSES design allowable strength by seven percent.

6.8.2 TENSILE FATIGUE -- The results from the tensile fatigue tests demonstrated that the deck/bulkhead element specimens as designed and produced had substantially lower axial fatigue strengths than the stiffened panels. This strength difference was primarily attributed to the abrupt changes in cross section at the bulkhead intersection coupled with larger longitudinal bowing distortions in the deck/bulkhead element specimens. When the critical point in the deck/bulkhead element was reworked before testing, tensile fatigue performance was improved to the point of being essentially the same as that for the comparable stiffened panels.

Without exception, the bulkhead intersection was the most fatigue sensitive area in the deck/bulkhead specimens. The sharp corner formed by the intersection of the bulkhead tee stiffener flange with the free edge of the deck flatbar stiffener was the critical point of failure origin for the specimens tested in the as-produced condition. Reworking this critical point before testing using improved welding techniques and past-weld contour smoothing produced nearly 50 percent increase in the tensile fatigue strength attained and shifted the point of failure origin. With the critical stiffener intersection point repaired or improved before testing, the toe of the fillet weld around the deck stiffener penetration through the bulkhead plate became the typical origin of failure.

In summary, it can be concluded that improved design and/or welding at the junctions of the bulkhead tee stiffeners with the deck flatbar stiffeners is required to achieve tensile fatigue performance comparable to that of the 3KSES basic stiffened panel structure.

7 / THREE-BAY PANEL ELEMENT TESTS

7.1 GENERAL

As the culminating phase of the Panel and Element Structural Test Program, combined loading tests were conducted on three-bay length stiffened panel elements representing an area of the 3KSES sidehull shell. These tests were performed in general accordance with Test Plan No. TTP00017, Reference 2, to acquire data on the buckling characteristics of flatbar stiffened panel structure subject to combinations of axial compression and surface pressure loadings. Four test specimen assemblies were fabricated and subjected to 17 separate test conditions as summarized in the Test Matrix, Table 7-1, and described in detail below.

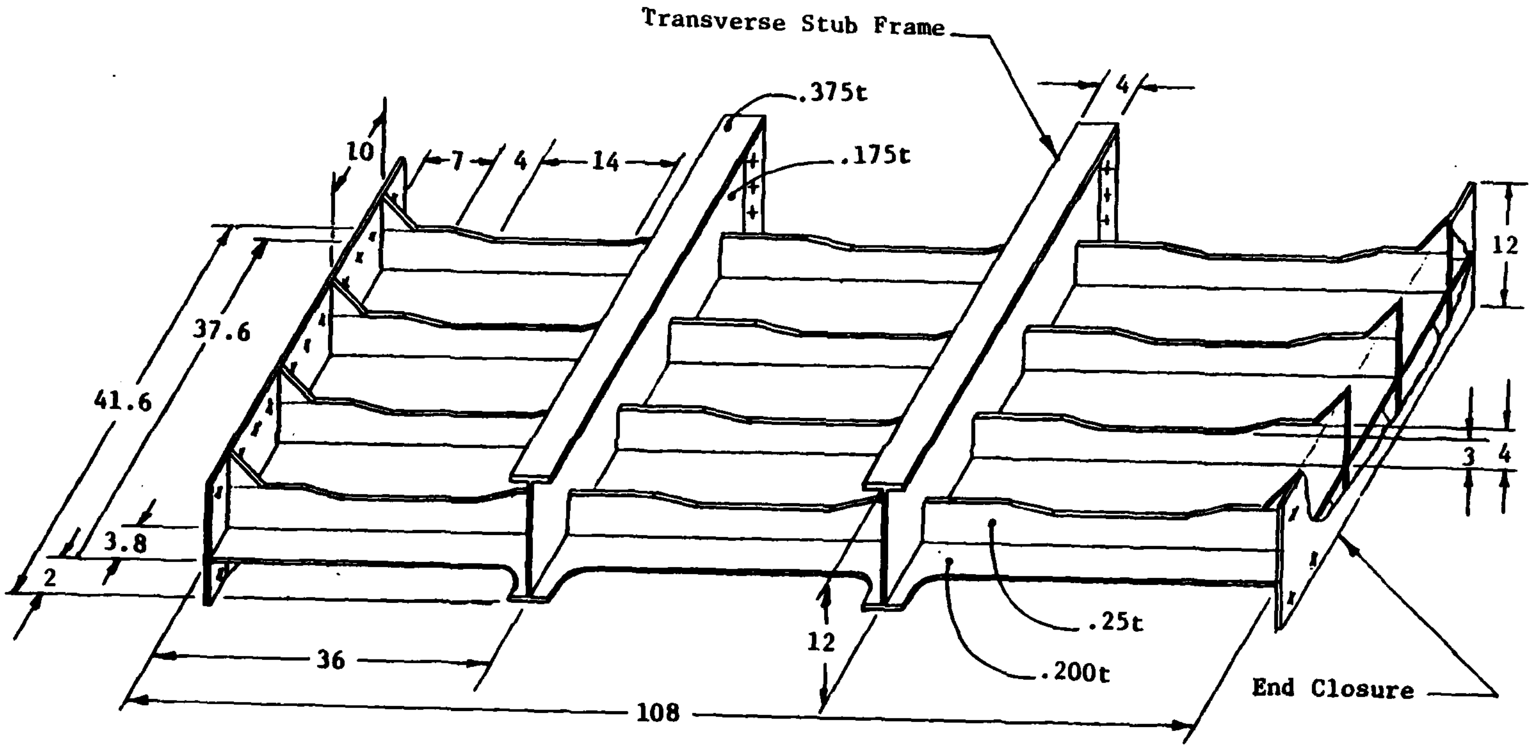
7.2 SPECIMEN DESCRIPTION

All four of the three-bay element assemblies fabricated for testing were of one basic configuration varying only with respect to stiffener distortions. The basic specimen configuration, representing a section of flatbar stiffened panel spanning four transverse frames on the 3KSES, is illustrated with nominal scantlings in Figure 7-1. As shown in this figure, each specimen consisted of a plate stiffened by four haunched flatbar longitudinal stiffeners and two intermediate transverse frame segments. The panel ends, which coincide with transverse frame locations, were specially configured to interface with the test fixturing

Table 7-1. Three-Bay Panel Element Test Matrix.

ASSEMBLY IDENTIFICATION	STIFFENER CONFIGURATION	ELASTIC TEST CONDITIONS				FAILURE TEST CONDITIONS	
		Normal Pressure Only	Axial Compression Only	Axial Compression with 4 psig Constant Pressure	Axial Compression with 8 psig Constant Pressure	Axial Compression Only	Combined Normal Pressure and Axial Compression
TT802041-1, Baseline	All straight	X	X	X	X		X
TT802041-1B, Baseline	All straight					X	
TT802041-3, Bowed Stiff.	All bowed 3/8"	X	X	X	X		
(1) TT802041-3 Mod, Bowed Stiff.	All bowed 3/16"	X	X	X	X		X
TT802041-9, Bowed Stiff.	One bowed 3/8"	-	-	-	-	-	-
(2) TT802041-3A Mod., Bowed Stiff.	All bowed 3/16"	X				X	

(1) Reworked TT802041-3 Assembly
(2) Reworked TT802041-9 Assembly



Note: All dimensions in inches.

Figure 7-1. Three-Bay Element Test Specimen Basic Configuration.

and provide moment end fixity restraint conditions. The stub ends of the transverse frame segments were also configured to mate with test fixturing load reaction fittings.

Within the basic three-bay element configuration, variations among the individual assemblies were limited solely to the number of center bay flatbar stiffeners which were laterally bowed and the magnitude of this distortion. RMI Drawing No. TT802041 (Reference Appendix A) completely defined all design aspects and fabrication requirements for the three-bay element assemblies.

In accordance with the Reference 2 test plan, a total of four assemblies were manufactured by RMI Production per Drawing No. TT802041. All were fully inspected and accepted by Quality Assurance. These assemblies were identified as TT802041-1, -1B, -3 and -9 with center bay stiffener distortions as noted in Table 7-1. The -1 and -B assemblies were essentially duplicates. After initial tests were completed on the -3 assembly, this element was reworked by the Rohr Industries Test Laboratory to reduce the amount of bowing distortion in all four center bay stiffeners from 3/8 to 3/16 inch. After rework, the identification of this assembly was changed to TT802041-3 Mod. Based on test results from other assemblies, the -9 assembly was reworked by the Rohr Industires Test Laboratory to duplicate the -3 assembly configuration before being subjected to any tests. Identification of the reworked -9 assembly was changed to TT802041-3A Mod. All of the rework performed by Rohr Industries was directed, inspected, and accepted by the RMI Test Monitoring Organization.

Each of the three-bay element test specimens was manufactured as a separate assembly of 5456-H116 or H117 aluminum alloy sheet and plate gas-metal-arc welded with 5556 aluminum alloy filler wire. All assemblies were initially produced to a nominally straight condition meeting proposed 3KSES acceptance standards. Where required, stiffener distortions were subsequently produced by laterally deforming the stiffener outstanding free edges to the specified contour.

Photographs illustrating two of the three-bay element assemblies after the completion of fabrication are presented in Figure 7-2. The thin longitudinal straps (Reference Part No. TT802041-65) shown in the photographs extending from the assembly ends over the transverse frames were subsequently cut or completely removed from each assembly prior to test. This action was taken after re-evaluation determined that the transverse frame stability was adequate without the straps present.

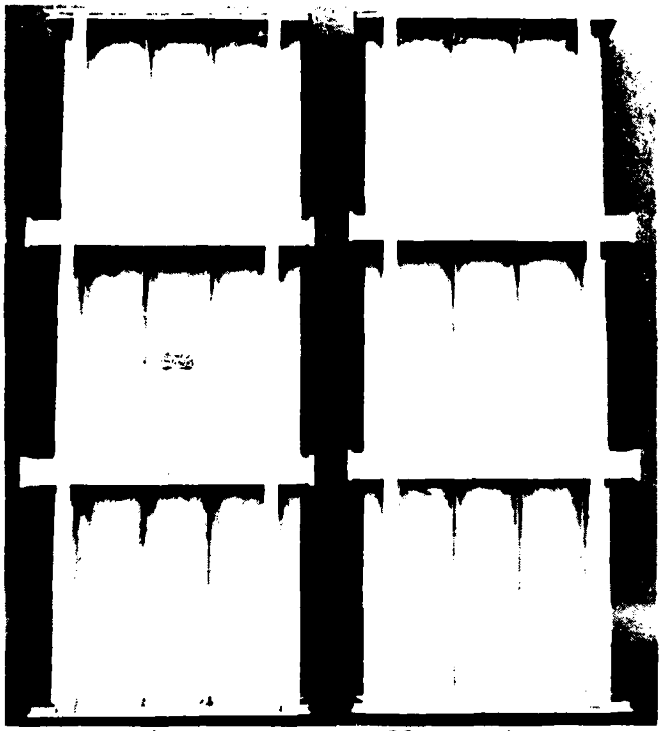
7.3 SPECIMEN PREPARATION

Prior to installation in the test setup, each three-bay element specimen was measured to determine actual dimensions at the locations indicated in Figure 7-3. Recorded measurements obtained from each specimen are presented in Table 7-2.

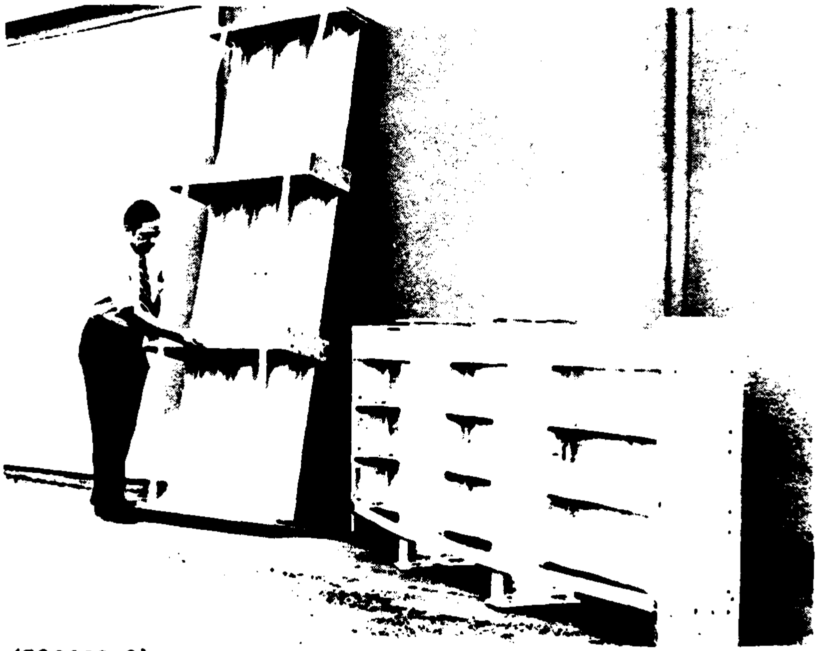
After measurements were completed, each three-bay element specimen was instrumented with a specified array of strain gages. Small self-adhesive clips were then attached to each specimen as required for subsequent connection to deflection transducer cables. Locations, orientations and other details of the strain gage and deflection transducer installations are described below in Section 7.5. When these tasks were completed, each specimen was ready for installation in the test setup.

7.4 TEST SETUP AND FIXTURES

All tests on the three-bay panel elements were conducted in the Rohr Industries Structural Test Laboratory located at the Chula Vista plant. The setup for these tests centered around a custom rig designed to properly support and restrain each specimen and apply the requisite axial compression and lateral pressure loads in any desired ratio. Detail design, fabrication, assembly and installation of this rig were the responsibility of the Rohr Industries Test Laboratory working to RMI specifications. Features of the rig, which combined standard laboratory components with special fixturing, are described below.

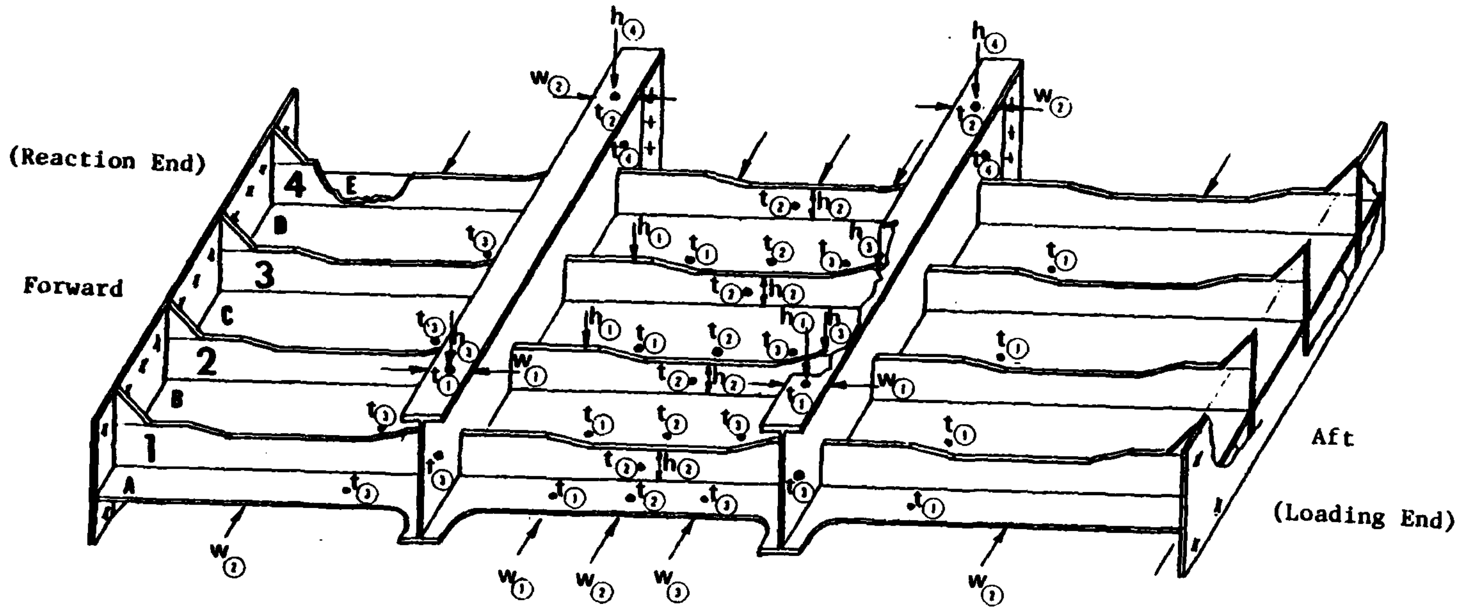


(780609-5) Note bowed stiffeners in center bay of left assembly



(780609-3)

Figure 7-2. Typical Three-Bay Panel Element Assemblies After Completion of Manufacture.



LEGEND: • t - Thickness of plate, stiffener, frame web, or frame flange

→ w - Width of plate or frame flange

↓ h - Net height of stiffener or frame

Figure 7-3. Three-Bay Element Specimen Pretest Measurement Locations.

Table 7-2. Three-Bay Element Specimen Pretest Measurements.

NOTE: Reference Figure 7-3 for Measurement Locations and Identifications.

FORWARD BAY MEASUREMENTS-INCHES

DIMEN.	SPECIMEN NO. 041-1	041-1B	041-3/ 041-3 Mod	041-9/ 041-3A Mod
$w_{\textcircled{1}}$	37.957	37.600	37.644	37.612
$t_{\textcircled{1}A}$	.205	.211	.203	.203
$t_{\textcircled{1}B}$	.207	.210	.203	.202
$t_{\textcircled{1}C}$	.208	.210	.203	.201
$t_{\textcircled{1}D}$	.210	.208	.203	.200
$t_{\textcircled{1}E}$	.210	.206	.203	.198

AFT BAY MEASUREMENTS-INCHES

DIMEN.	SPECIMEN NO. 041-1	041-1B	041-3/ 041-3 Mod	041-9/ 041-3A Mod
$t_{\textcircled{1}A}$	.202	.209	.201	.201
$t_{\textcircled{1}B}$	.204	.207	.203	.202
$t_{\textcircled{1}C}$	.206	.206	.204	.201
$t_{\textcircled{1}D}$	.207	.205	.204	.199
$t_{\textcircled{1}E}$	.207	.203	.204	.197
$w_{\textcircled{1}}$	37.654	37.620	37.572	37.605

TRANSVERSE FRAME MEASUREMENTS-INCHES

DIMEN.	SPECIMEN NO. 041-1		041-1B		041-3/ 041-3 Mod		041-9/ 041-3A Mod	
	FWD	AFT	FWD	AFT	FWD	AFT	FWD	AFT
$t_{\textcircled{1}}$	.556	.558	.558	.551	.556	.552	.553	.555
$w_{\textcircled{1}}$	3.991	3.997	3.995	4.012	3.996	4.012	4.010	4.002
$t_{\textcircled{1}}$	.553	.553	.554	.557	.554	.556	.560	.552
$w_{\textcircled{1}}$	4.008	4.000	4.017	3.997	4.017	4.013	3.987	4.014
$t_{\textcircled{1}}$	.279	.280	.280	.274	.277	.277	.281	.281
$h_{\textcircled{1}}$	11.869	11.930	11.971	11.948	11.966	11.930	12.002	11.939
$t_{\textcircled{1}}$	.280	.280	.278	.278	.279	.277	.284	.286
$h_{\textcircled{1}}$	11.959	11.905	11.985	12.014	11.933	11.934	11.933	11.925

CENTER BAY MEASUREMENTS-INCHES

FORWARD CROSS-SECTION DIMEN.	SPECIMEN NO. 041-1	041-1B	041-3/ 041-3A	041-9/ 041-3A Mod
$w_{\textcircled{1}}$	37.580	37.595	37.600	37.600
$t_{\textcircled{1}A}$	.205	.211	.200	.203
$t_{\textcircled{1}B}$	.208	.210	.209	.206
$t_{\textcircled{1}C}$	.208	.210	.202	.203
$t_{\textcircled{1}D}$	.210	.207	.204	.201
$t_{\textcircled{1}E}$	.210	.205	.202	.199
$h_{\textcircled{1}2}$	4.037	4.016	3.971	4.004
$h_{\textcircled{1}3}$	4.000	4.025	3.975	3.966

MID CROSS-SECTION DIMEN.	SPECIMEN NO. 041-1	041-1B	041-3/ 041-3 Mod	041-9/ 041-3A Mod
$w_{\textcircled{1}}$	37.650	37.592	37.617	37.605
$t_{\textcircled{1}A}$	.205	.211	.201	.204
$t_{\textcircled{1}B}$	.206	.210	.201	.204
$t_{\textcircled{1}C}$	.208	.208	.210	.203
$t_{\textcircled{1}D}$	.208	.206	.209	.200
$t_{\textcircled{1}E}$	.209	.205	.204	.199
$t_{\textcircled{1}1}$	.255	.261	.252	.254
$h_{\textcircled{1}1}$	2.988	3.009	2.970	3.008
$t_{\textcircled{1}2}$	.263	.261	.257	.252
$h_{\textcircled{1}2}$	3.047	2.987	3.028	2.956
$t_{\textcircled{1}3}$	.256	.264	.255	.256
$h_{\textcircled{1}3}$	3.006	3.032	2.995	2.930
$t_{\textcircled{1}4}$	.258	.260	.258	.250
$h_{\textcircled{1}4}$	3.034	3.012	2.970	2.995

AFT CROSS-SECTION DIMEN.	SPECIMEN NO. 041-1	041-1B	041-3/ 041-3 Mod	041-9/ 041-3A Mod
$w_{\textcircled{1}}$	37.629	37.581	37.590	37.585
$t_{\textcircled{1}A}$	.203	.209	.200	.204
$t_{\textcircled{1}B}$	.207	.208	.200	.202
$t_{\textcircled{1}C}$	.207	.207	.201	.204
$t_{\textcircled{1}D}$	.207	.206	.203	.201
$t_{\textcircled{1}E}$	.207	.203	.203	.198
$h_{\textcircled{1}2}$	4.030	4.019	3.981	4.000
$h_{\textcircled{1}3}$	4.010	4.047	3.967	3.967

The basic test setup for the three-bay element tests is depicted in Figure 7-4. A dominant features of this eetup was the test rig horizontal steel frame which was mounted to the laboratory floor and used for applying and reacting the axial compression loading. The three-bay element test specimen was contained inside this frame oreinted with the stiffener/frame side upward. To provide the required specimen end moment fixity conditions, the test rig axial loading head was supported and stabilized by sets of vertical and horizontal links equipped with spherical bearings at both ends. A spherical bearing lug was also employed to connect the loading head to the strain gage load cell and hydraulic actuator, both of which are further described below. A rubberized fabric water pressure bladder, measuring 96 inches by 38.6 inches by 4 inches deep, was supported in an open-top steel containment structure located underneath the three-bay element specimen and mounted from the laboratory floor. Spherical bearing links were also mounted from the bladder containment structure and connected to lug fittings installed on the ends of the specimen stub frames. Additional definition of the custom test rig is provided on Rohr Industries Drawing No. 501-392 (Reference Appendix A).

A view of the basic three-bay element test rig prior to installation of the pressure bladder is shown in Figure 7-5. After the pressure bladder was installed and partially filled with water, strips of rubber sheeting were foled in place along each edge of the bladder, and the entire surface of exposed rubber was dusted with talcum powder as shown in Figure 7-6 to reduce abrasion and friction. A slip sheet of polyethylene film was subsequently placed over the top surface of the bladder to further reduce friction and protect the strain gages installed on the smooth surface of the test specimen contacted by the bladder.

A 14 inch bore, 8 inch stroke, commercial style hydraulic actuator attached to a dual channel load cell, calibrated to 500,000 pounds load, was utilized to apply axial compression to the test specimens. A manual

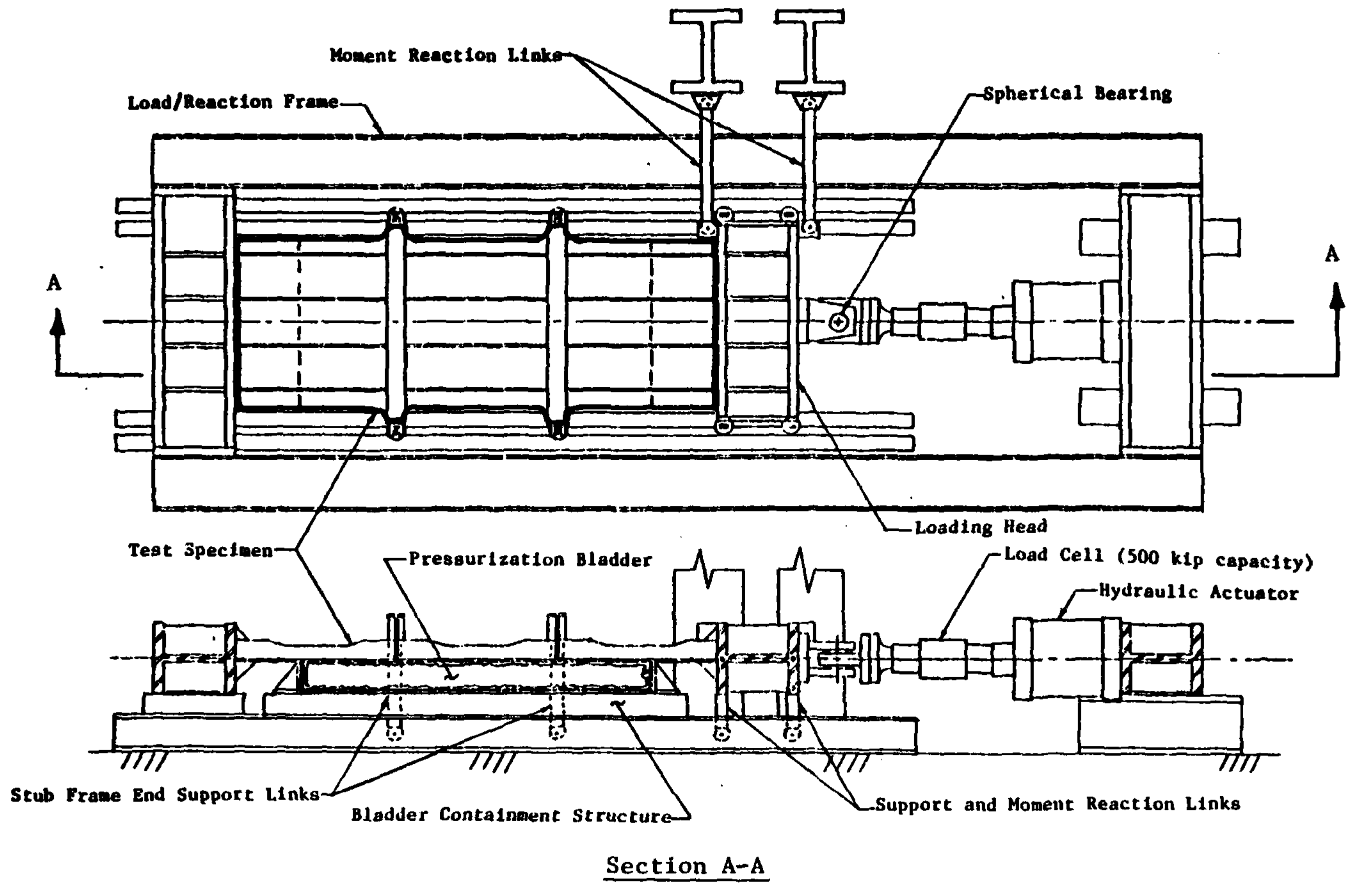


Figure 7-4. Three-Bay Element Combined Loading Test Rig.

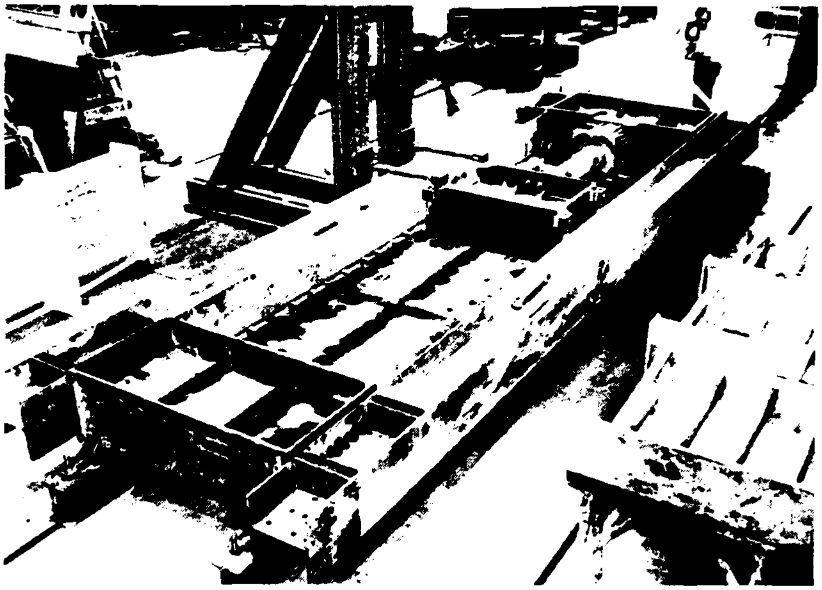


Figure 7-5. (790426-3) Load/Reaction Frame Setup for Three-Bay Element Tests

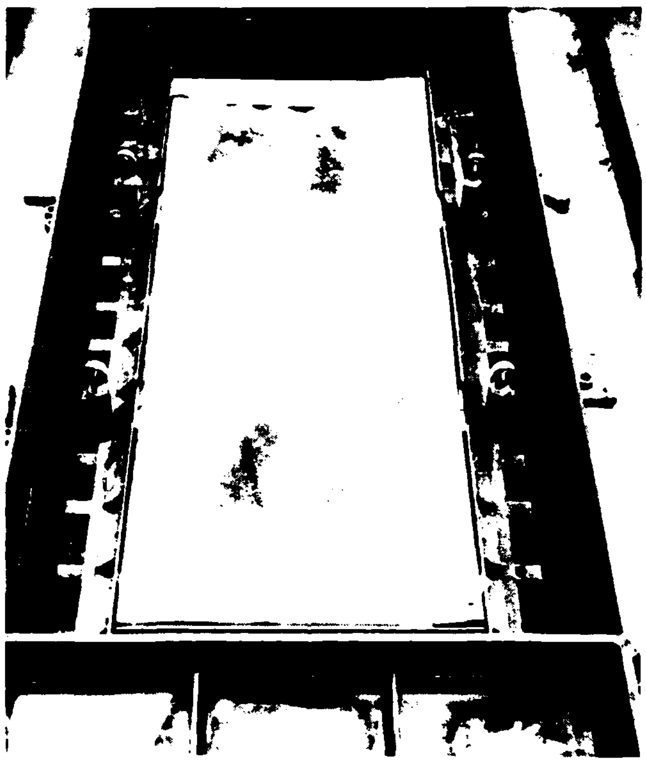


Figure 7-6. (79-373-2) Pressure Bladder Ready for Specimen Installation. Note containment rails along sides and ends.

lever-operated hydraulic pressure pump was employed to allow precise control of the actuator pressurization. The applied axial load was displayed to the pump operator on a standard Budd strain indicator connected to one channel of the load cell. The combined accurary of the load cell and strain indicator was within one percent of the maximum capacity as established by end-to-end calibration performed by United Calibration Corp. prior to the start of testing. This calibration conformed to MIL-C-45662A, Reference 14, and was traceable to the National Bureau of Standards. Pressurization of the bladder utilized to apply normal surface pressure to the three-bay element specimens was controlled through a manifold connected to the plant tap water supply. This manifold included a 0 to 50 psig adjustable pressure regulator, inlet and bleed needle valves, and arelief dump valve set to 40 psig. A 100-inch mercury manometer connected to the bladder outlet port was utilized to gain precision in pressurization control and read-out. The least graduation on the manometer scale was 0.10 inch.

An independently mounted deflection measurement framework was constructed and installed over the central potion of the load/reaction frame and the test specimen. This framework mounted a total of 23 deflection transducers which were connected by wire fishing leader and snap swivels to the clips attached on each specimen. With this concept, the swivels could be disconnected and the entire framework readily removed to facilitate test specimen viewing, rework and/or replacement. A photograph of the completed three-bay element combined loading test setup is presented in Figure 7-7. A close-up view of the installed deflection transducer framework is shown in Figure 7-8.

7.5 INSTRUMENTATION AND DATA ACQUISITION EQUIPMENT

Standard commercial uniaxial strain gages, Micro-Measurements Type EA-13-250BG-120(W) were bonded to each three-bay element specimen at designated locations using Rohr Industires test laboratory standard installation procedures. Characteristics of the selected strain gages included 1/4 inch gage length, 120 ohm basic resistance, temperature balanced for

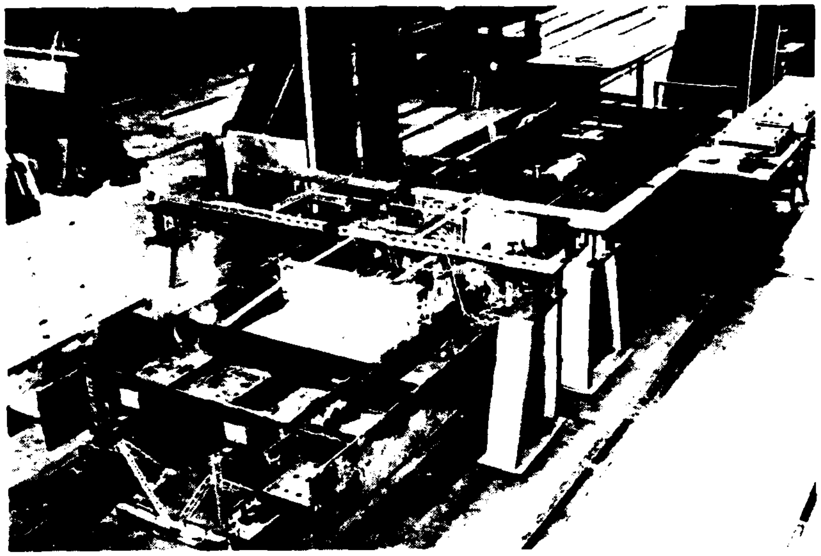


Figure 7-7. (790585-2) Overall View of Completed Three-Bay Element Test Setup

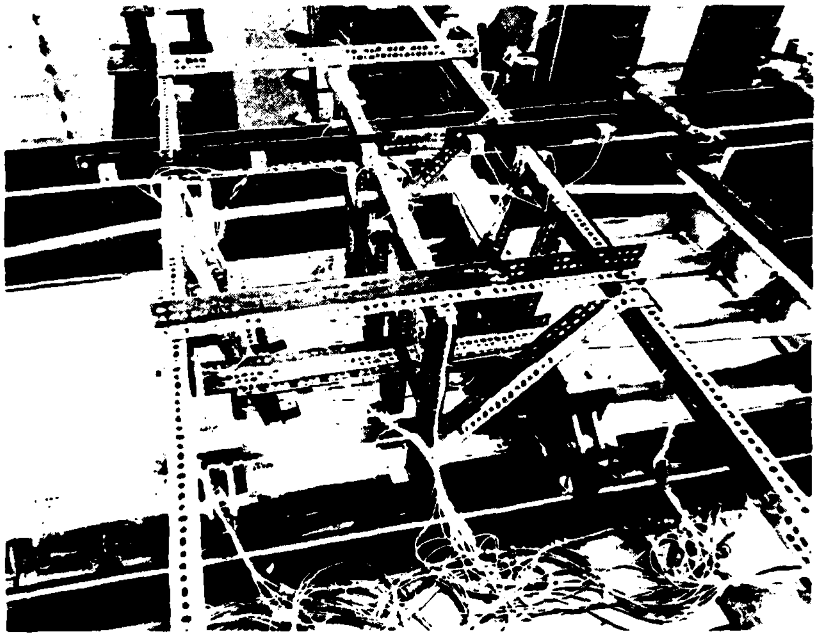
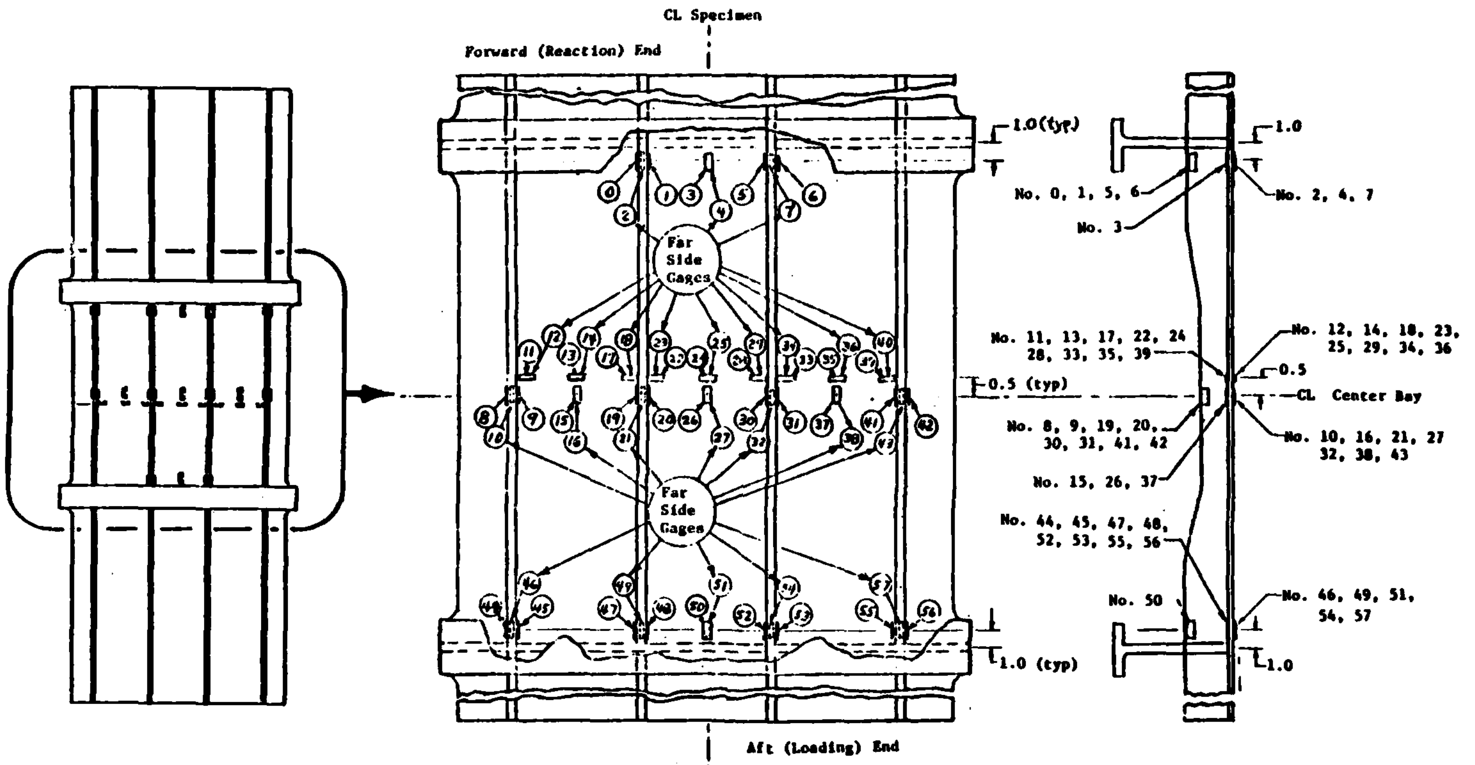


Figure 7-8. (790613-3) Detail of Deflection Transducer Installations and Removable Mounting Frame.

use on aluminum and a rated static strain range of $\pm$ 0.005. In general, a total of 58 strain gages was installed on each three-bay element test specimen at the locations and orientations depicted in Figure 7-9. In accordance with the Reference 2 test plan, these locations were intended to verify the uniformity of applied loading and determine the strain distributions under each test condition. As indicated on Figure 7-9, certain strain gages in locations judged non-critical were omitted from the final specimen tested (Element No. TT802041-1B). A total of 23 displacement transducers was mounted in the removable framework previously described to measure specimen deflections at the locations and orientations shown in Figure 7-10. These transducers were Research Inc. rotary potentiometers, Model 4046-2, each providing a 2-inch total stroke capability with 0.004 inch resolution.

All strain gages, rotary potentiometer deflection transducers, and the second channel of the axial compression load cell were connected to a B & F Instruments Model 256 digital data acquisition system with 260 channel capacity. This data system contained the necessary signal conditioning to output all data directly in engineering units, i.e., strain in micro-inches per inch, displacements in 0.001 inch, and applied axial load in units of 100 pounds. Upon command, the data system produced a paper tape print-out of the date, time of day, and all reduced data readings at the rate of 20 channels per second. Rated range of the B & F data system was $\pm$ 10,000 units on each channel with a rated accuracy of $\pm$ 10 units.

Prior to the start of testing, thebasic B & F data system was calibrated against voltage standard by the Rohr Industries Test Laboratory Instrumentation Group. The voltage standard used, EDC DC voltage calibrator Model 2902, Serial No. 6447, showed evidence of current calibration by National Astro Laboratories against National Bureau of Standards calibrated standard. Prior to the start of each test condition, all strain gages were end-to-end calibrated with the assigned data system channels and connecting cables to the manufacturer's certified gage factor

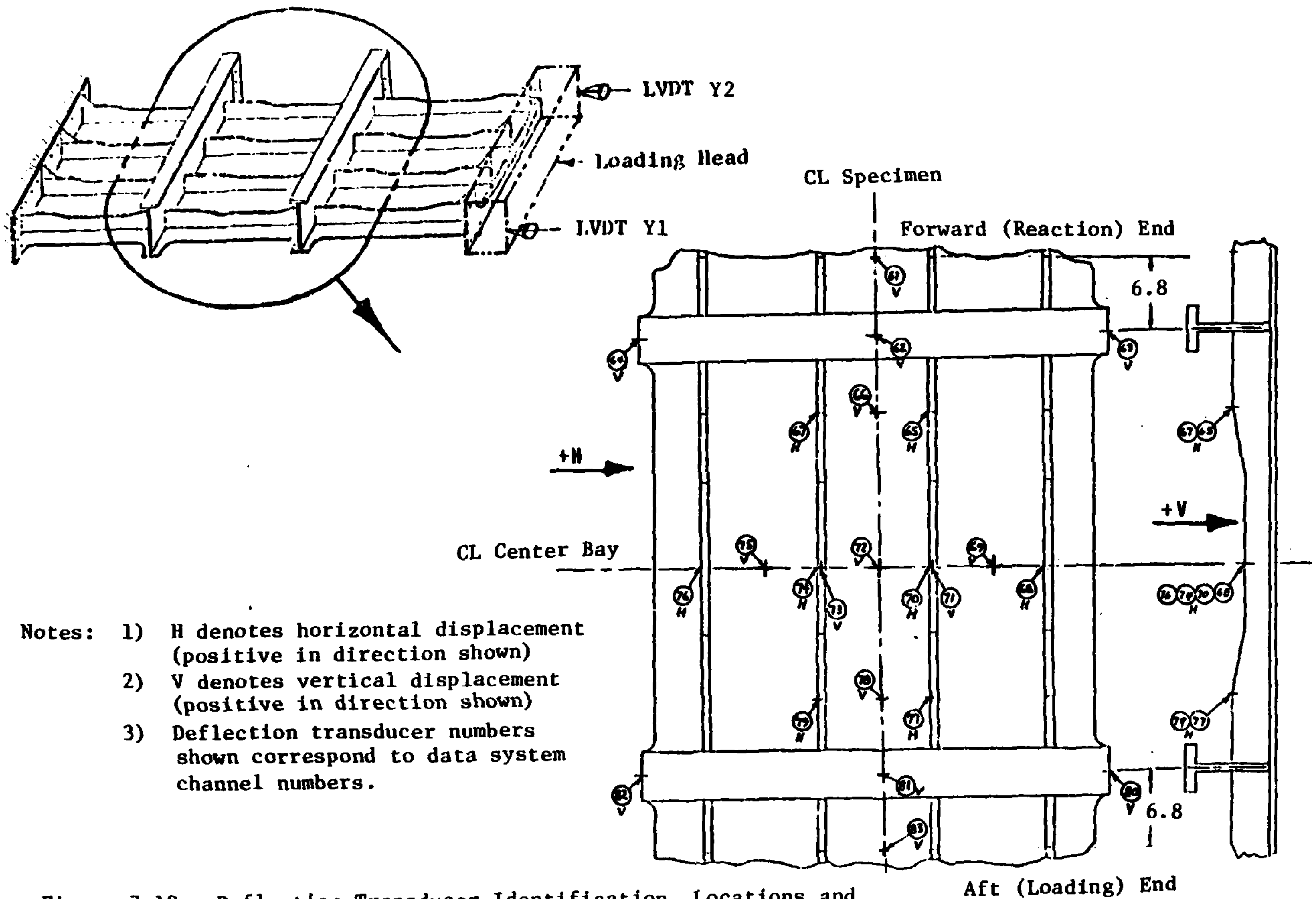


Notes: 1) Strain gage numbers shown correspond to data system channel numbers.

2) Strain gages No. 11, 12, 13, 14, 24, 25, 35, 36, 39 and 40 not installed on Element No. TT802041-1B.

3) Strain gages No. 15, 26, and 37 shifted laterally 3/16 inch on Element No. TT802041-3A Mod to avoid punch marks.

Figure 7-9. Strain Gage Identification, Locations and Orientations on Three-Bay Element Specimens.



Notes:
1) H denotes horizontal displacement (positive in direction shown)
2) V denotes vertical displacement (positive in direction shown)
3) Deflection transducer numbers shown correspond to data system channel numbers.

Figure 7-10. Deflection Transducer Identification, Locations and Orientation on Three-Bay Element Specimens.

furnished with the strain gages. At the same time all rotary potentiometers were end-to-end calibrated with the assigned data system channels and connecting cables using precision gage blocks.

In addition to the above instrumentation, two G.L. Collings Model SS-409 LVDT's (Linear Variable Displacement Transformer) with 4-inch stroke capacity were mounted to measure travel of the test rig loading had as shown in Figure 7-11. (Measurement of the loading head travel was essentially a measurement of the test specimen axial deformation.) The outputs from these LVDT's and the second channel of the axial compression load cell (also connected to the B&F data system) were required on a Hewlett-Packard Model No. 7046A X-Y-Y chart recorder. This recorder handled chart sizes up to 11 inches by 17 inches with a rated accuracy ± one percent of full scale. The X-Y-Y recorder was calibrated to plot directly in engineering units; i.e., displacements in inches and load in pounds. A photograph showing both the B&F data system and the Hewlett-Packard X-Y-Y recorder setup during test is presented in Figure 7-12.

Supplementing the above, two Starrett dial deflection indicators were mounted from the laboratory floor to measure any horizontal displacement at the reaction end of the test rig main frame as indicated in Figure 7-13. Additional dial deflection indicators were added at various points during the course of testing to measure specimen plate edge vertical and stub frame horizontal displacements. The locations and utilization of these additional indicators are also shown on Figure 7-13. Each of the dial indicators used provided a total displacement range of 1.0 inch with a rated accuracy of 0.001 inch.

The Rohr Industries Test Laboratory Instrumentation Group was responsible for the implementation, checkout, and calibration of all equipment used in the generation of loads and the acquisition of all data during the course of three-bay element testing. All instrumentation was subject to the laboratory's quality assurance provisions instituted to

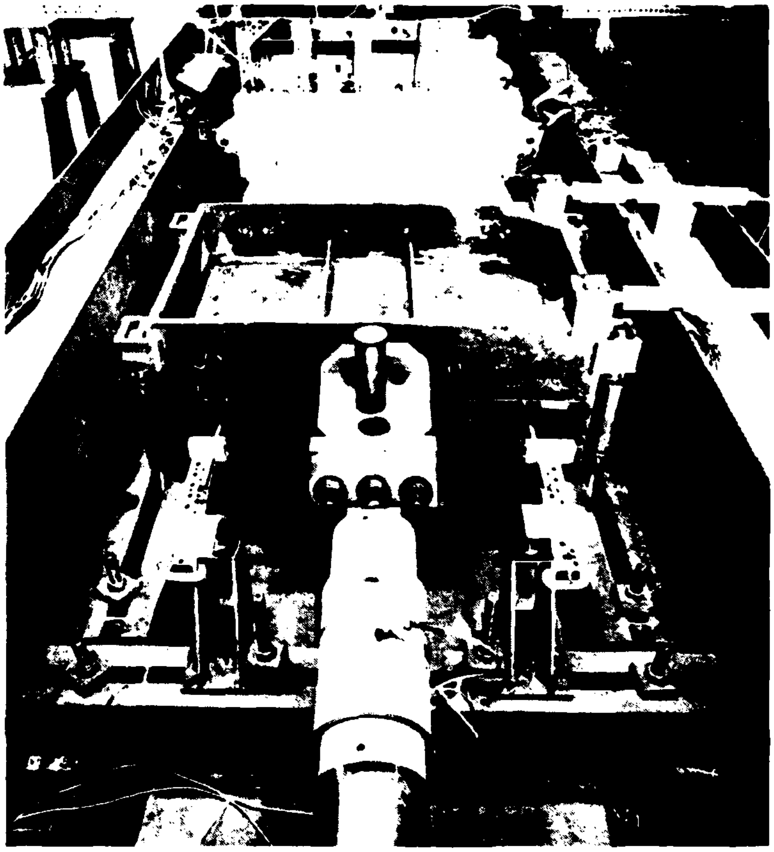


Figure 7-11. (790613-4) Loading Head Detail View Showing LVDT Installations to Measure Head Travel.

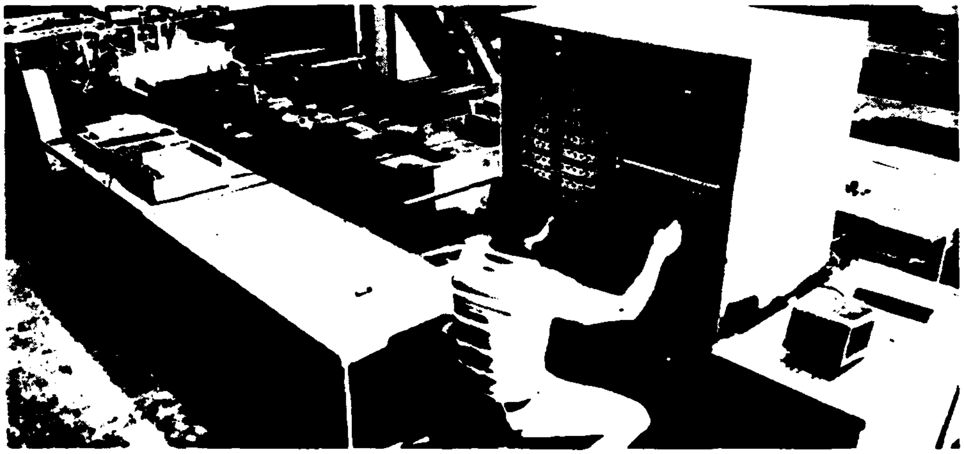
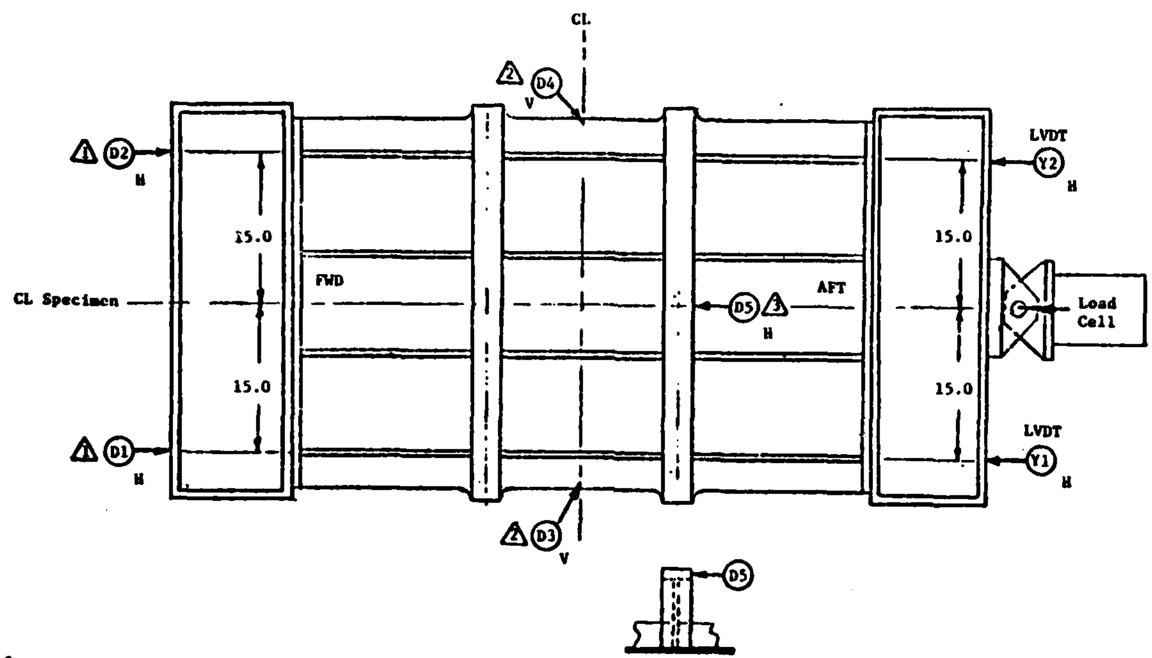


Figure 7-12. (790585-1) Data Acquisition System and X-Y-Y Recorder Setup for Test.



NOTES: 1 Dial gages installed for elastic axial compression test on TT802041-1 and all subsequent tests.

2 Dial gages installed for elastic axial compression/8 psig pressure test on TT802041-1 and all subsequent tests.

3 Dial gage installed for elastic axial compression/8 psig pressure test on TT802041-3 and all subsequent tests.

4) H denotes horizontal displacement; V denotes vertical displacement.

Figure 7-13. Dial Deflection Indicator and LVDT Installations for Three-Bay Element Tests.

preserve data precision and accuracy including National Bureau of Standards traceability. Calibration systems were in conformance with MIL-C-45662A, Reference 14. All instrumentation used during the three-bay element tests displayed evidence of current calibration certification.

7.6 TEST PROCEDURES

7.6.1 GENERAL -- In order to obtain the maximum amount of data from each test specimen configuration, two basic categories of tests were performed. The first category of testing was intended to determine the elastic behavior of each basic specimen configuration under four test conditions. These conditions included axial compression loading, normal pressure loading and two combinations thereof. All strain gage data was carefully monitored during the progress of each test, and testing was terminated in each case when the onset of permanent set was detected. This approach was intended to preserve the original specimen condition for all subsequent tests. The second basic category of testing constituted a final test to specimen failure under a slected critical loading condition.

Detailed procedures for all tests are described in the sections below.

7.6.2 PRE-TEST PREPARATIONS -- As the first step in preparation for test, clevis fittings were attached to the stub frame ends of the selected three-bay element specimen on which strain gages had been previously installed. After the water pressure bag had been partially filled, the test specimen was positioned into the test fixture and loosely bolted to the loading and reaction heads leaving a nominal 1/4 inch gap between the specimen bearing plate and the head at each end. The stub frame end reaction links were connected to the specimen after the lengths of these links had been adjusted for proper fit to the particular specimen. With the specimen properly aligned, the gaps at each end were filled with liquid Devcon "Plastic-Steel." After the potting material had cured, the specimen end bolts were tightened to

provide theprovide the required moment resistant connection. This end potting technique was employed to assure maximum uniformity of the applied axial load distribution between the test fixture and the specimen.

On the initial three-bay element specimen tested, the two thin straps incorporated on the specimen to assure stub frame stability in roll were cut through at one end in each bay. This action was taken to preclude any incluence on the specimen test performance after a re-evaluation determined that these straps were unnecessary. On all subsequent specimens, these straps were completely removed to enhance visibility and access to the specimen during testing.

The deflection transducer framework was then positioned in place and the transducer lead wires were connected to the specimen. All instrumentation was connected to the data acquisition system, and each channel was set to zero, balanced and end-to-end calibrated to read directly in the appropriate engineering units. When these preparations were completed, testing was ready to commence.

7.6.3 ELASTIC TEST CONDITIONS -- Testing to determine speciment elastic behavior encompassed a total of our separate test conditions as follows:

a. Normal pressure loading only (applied to the deck plate side opposite the stiffeners).

b. Axial compression loading only.

c. Axial compression loading combined with a constant normal pressure of 4 psig.

d. Axial comprssion loading combined with a constant normal pressure of 8 psig.

All four of the above conditions were applied to three-bay element test specimens TT802041-1 (Baseline, all stiffeners initially straight) and TT802041-3 (all center bay stiffeners initially bowed 3/8 inch). After completing the four elastic test conditions, the latter of the above specimens was reworked to the TT802041-3 Mod configuration (initial bowing of all center bay stiffeners reduced to 3/16 inch), and all four elastic test conditions were repeated. In addition, the normal pressure only condition was applied to specimen TT802041-3A Mod (all center bay stiffeners initially bowed 3/16 inch) to obtain a second set of data for comparison purposes.

7.6.3.1 Normal Pressure Test Procedures -- For all tests conducted with normal pressure only, the pin through the lug fitting connecting the test fixture loading head to the load cell and hydraulic actuator was removed to preclude axial loading or restraint on the specimen. Immediately prior to the start of testing, all data system channels were final adjusted to nominal zero readings and these readings were recorded. A record of strain gage resistance calibration data was also produced.

Normal pressure was initially applied to the specimen in increments of 2.0 psig as measured from the mercury manometer. All data was recorded at each load increment, and the strain data was carefully examined for evidence of the onset of permanent strain. Real-time plots of the data from selected critical strain gages were also made to detect the onset of non-linearity. When indications of possible permanent set were detected, the applied pressure was reduced to 2.0 psig and all data was recorded for comparison to the initial data recorded at 2.0 psig. Whenever the applied pressure was reduced to record such reference data, the pressure was first reduced to approximately 1.0 psig and then increased back to 2.0 psig in order to minimize hysteresis effects.

If permanent strain was not clearly apparent from comparison between the two sets of data recorded at 2.0 psig, the applied pressure was increased to the next scheduled load increment. As testing progressed, the load increments were normally reduced to 1.0 psig. The actual sequence of test loading/data recording increments is delineated on the summary table contained in Appendix G for each test conducted. The process of incrementally increasing the applied pressure load with periodic returns to the 2.0 psig reference level was continued until positive evidence of the onset of permanent strain was detected. After permanent set was detected, final data recordings were made at 2.0 psig and post-test zero load levels. A post-test recording of strain gage resistance calibration data was also made. At the conclusion of testing, each specimen remained in the test setup for the next scheduled phase of testing.

7.6.3.2 Axial Compression Test Procedures -- For all tests conducted with axial compression loading only, the water pressure bag was partially drained to preclude interference with the specimen buckling behavior. With the hydraulic actuator and load cell disconnected from the loading head, all data system channels were final adjusted to nominal zero readings immediately prior to the start of testing. Both these readings and the strain gage resistance calibration data were recorded. After the loading head was reconnected to the load cell and actuator, the initial zero-load data was recorded.

Axial load was initially applied to the specimen in increments of 2.0 ksi nominal stress hased on the minimum cross section area of each specimen calculated from the actual specimen measurements. Control and monitoring of the applied axial load was accomplished using a Budd strain indicator connected to one channel of the load cell as the master source for load readout. All data was recorded at each load increment with close review of the strain data and real-time plotting performed as described above in Section 7.6.3.1.

Whenever possible indications of permanent set were detected, the axial load was first reduced below and then increased back to the equivalent of 2.0 ksi nominal stress in order to record comparative data. If permanent strain was not clearly apparent from comparison between the two sets of data recorded at 2.0 ksi nominal stress, axial loading was increased to the next scheduled increment. The actual sequence of test loading/data recording increments is defined on the summary table contained in Appendix G for each test conducted. The process of incrementally increasing axial load with periodic returns to the 2.0 ksi reference level was continued until positive evidence of permanent set was obtained. Final zero-load data recordings were made both prior to and after disconnecting the loading head from the load cell/actuator string. Post-test strain gage resistance calibration data was also recorded. At the completion of axial load testing, each specimen remained in the test fixture for the next scheduled test phase.

7.6.3.3 Combined Loading Test Procedures -- As previously defined, tests to the elastic limit under combined loading encompassed two test conditions. In both conditions, the normal pressure was applied and held constant while the axial compression load was incrementally increased. The procedures for both test conditions were essentially identical except for the magnitude of the applied normal pressure.

Immediately prior to the start of testing, all data channels were final adjusted to nominal zero readings. For this process, the water pressure bag was partially drained and the loading had was disconnected from the load cell/actuator string. Separate recordings of the zero readings and the strain gage resistance calibration data were made. A second set of initial zero-load data was recorded after the loading head was reconnected to the load cell/actuator string.

The water pressure bag was then filled, and for the first test condition, pressure was increased to 4.0 psig after which all data was recorded. The normal pressure was constantly monitored and maintained at 4.0 psig through the remainder of the test. Axial load was then applied to the specimen in initial increments of 2.0 ksi nominal stress based on the minimum cross-section area of the particular specimen. All data was recorded at each load increment with close monitoring of the strain data and real-time plotting performed as previously described. To check for permanent strain, the axial load was reduced below and increased back to 2.0 ksi nominal stress, while the pressure was maintained constant, to record comparative data. Testing continued by incrementally increasing the axial load, coupled with periodic returns to the 2.0 ksi nominal stress reference level, until firm evidence of permanent set was obtained. The actual sequence of applied loading/ data recording increments is delineated on the summary table contained in Appendix G for each test conducted.

Final data recordings were made after all axial load was removed with pressure remaining, and after all loading was removed. In the latter case, data was recorded both before and after disconnecting the loading head from the load cell/actuator string. Strain gage post-test resistance calibration data was also recorded.

The entire procedure described above, starting with the zero reading adjustments to the data system, was repeated with a normal pressure of 8.0 psig applied and held constant. At the completion of this second test condition, each specimen remained in the test setup in preparation for the next scheduled test phase.

After completing both combined loading test conditions, the TT802041-3 specimen was reworked, while installed in the test setup, to the -3 Mod configuration by reducing the magnitude of the initial prebow in the center bag stiffeners. The full series of tests to the elastic limit was then repeated on the reworked specimen.

7.6.4 FAILURE TEST CONDITIONS -- Testing to determine the ultimate load-carrying capabilities and the failure characteristics of the three-bay element specimens encompassed two separate test conditions:

a. Axial compression loading combined with normal pressures applied to the plate side opposite the stiffeness;

b. Axial compression loading only.

For the combined loading tests to failure, the normal pressure was applied and increased in direct proportion to the axial load. The ratio of 1.0 psig normal pressure to 0.605 ksi nominal axial compression stress was selected to duplicate the critical design condition for a 3KSES panel with refined scantlings closest to those of the three-bag element test specimens. A second criteria for selection of the critical combined loading condition was a load ratio which was approximately midway between axial loading only and normal pressure only.

Testing to failure under axial compression only was added after examining the results from the initial combined loading tests. These results indicated that the application of pressure to the smooth side of the plate may enhance the axial load-carrying capability of structure with haunched flatbar stiffeners.

Tests to failure under the combined load condition were conducted on three-bay element test specimens TT802041-1 (Baseline; all stiffeners initially straight) and TT802041-3 Mod (All center bay stiffeness initially lowed 3/16 inch). Tests to failure under axial compression only were conducted on specimens of duplicate configurations; i.e., TT802041-1B (Baseline) and TT802041-3A Mod (All center bag stiffness bowed 3/16 inch). Detailed procedures for each type of test to failure are described in the sections below.

7.6.4.1 Combined Loading Test Procedures -- Immediately prior to the start of test, all data system channels were final adjusted to nominal zero readings and all pretest data was acquired in the same manner as described in Section 7.6.3.3 above. Testing was initiated by applying increments of normal pressure and axial load. Pressure was selected as the independent variable and applied in initial increments of 2.0 psig. After the pressure increment was applied, the axial load increment was applied at the ratio equivalent to 0.605 ksi nominal compression stress per 1.0 psig normal pressure. The magnitude of the applied axial load at each increment was based on the minimum cross-section area of the particular specimen computed from actual measurements. When the applied pressure and corresponding axial load were stabilized at each increment, all data was recorded. As testing progressed, the loading increments were normally reduced to half the original magnitude. The actual applied loading/data recording increments for each test performed are delineated on the appropriate summary tables contained in Appendix G.

The process of increasing first the normal pressure followed by the axial load was continued until the specimen load dropped off or the specimen would no longer accept additional loading. All data was recorded at each loading increment. After data was recorded at the maximum sustainable load condition, both the normal pressure and the axial load were proportionally reduced below and then increased back to repeat the initial test loading increment, i.e., 2.0 psig pressure and 1.21 ksi nominal compression stress. After data was recorded, the pressure and axial load were increased continuously in proportion until the maximum sustainable post-buckling load was reached at which time all data was again recorded. Loading was then released to zero, and a post-test record of strain gage resistance calibration data was produced.

For three-bay element specimen TT802041-1 Baseline, Two attempts were necessary to perform the combined loading tests to failure. The first attempt was aborted by failure of the hydraulic pump used to apply axial load. The second, and successful, attempt was conducted as a continuation with only selected increments from the first attempt duplicated to obtain comparative data.

At the completion of testing, each specimen was removed from the test setup and photographs were taken to document the buckling failure modes.

7.6.4.2 Axial Compression Test Procedures -- For the tests to failure, all procedures and data acquisition prior to the application of load were identical to those described above in Section 7.6.3.2. Axial load was initially applied in increments of 2.0 ksi nominal compression stress which were reduced to 1.0 ksi as testing progressed into the higher load levels. The actual test loading/data recording sequences for each test conducted are defined on the applicable summary table contained in Appendix G. Loading was increased until the specimen load dropped off or the specimen would no longer accept additional loading. Loading was then reduced to zero and all data was again recorded. On specimen TT802041-1B (Baseline), axial load was re-applied and steadily increased until a peak post-buckling load was attained. Loading was again reduced to zero, and post-test strain gage resistance calibration data was recorded.

At the completion of testing, the specimen was removed from the test setup, and photographs were taken to document the buckling failure modes.

7.7 TEST RESULTS

Complete tabulations of all strain and deflection data recorded during both the elastic behavior tests and the tests to failure on the three-bay panel element specimens are provided in Appendix G for reference. The recorder plots of axial compression load versus loading head travel (axial displacement) for all tests involving axial load are also provided in Appendix G.

7.7.1 ELASTIC LIMIT TEST RESULTS -- The results from all tests conducted to examine the behavior characteristics of the various three-bay element specimens within the elastic regime are summarized in Table 7-3. From the test data acquired, elastic limit interaction curves for combined loading were plotted for each specimen configuration as shown in Figure 7-14. This figure illustrates that the elastic performance of the specimen with the center bay stiffeners pre-bowed 3/16 inch was, in general, superior to that of the baseline specimen with all stiffeners initially straight. The baseline specimen exhibited overall superior performance only when subjected to axial compression without normal pressure. Except for loading under normal pressure only, the specimen configuration with the center bay stiffeners prebowed 3/8 inch exhibited significantly degraded performance levels.

Plots of the more significant strain data recorded from each specimen and associated elastic test condition are presented in Figures 7-15 through 7-18

7.7.2 FAILURE TEST RESULTS -- The results from the tests to failure conducted on the four three-bay element specimens are also summarized in Table 7-3. As seen from these results, the failure conditions and characteristics for specimens with the center bay stiffeners prebosed were essentially identical to those for the specimens with initially straight stiffeners. This result was applicable both to tests conducted with combined axial compression and normal pressure loading as well as tests with axial compression loading only. Comparison of the failure test results presented in Table 7-3 also shows that the simultaneous application of normal pressure had no effect on the axial compression failure stress for the specimens with initially straight stiffeners. For the specimens with prebowed center bay stiffeners, the simultaneous application of normal pressure caused only slight degradation (less than 5 percent) in the axial compression stress at failure.

Table 7-3. Three-Bay Panel Element Test Results Summary.

SPECIMEN DESCRIPTION		TEST CONDITION	RESULTS							
			ELASTIC LIMITS				FAILURE			
SPECIMEN NO.	CHARACTERISTIC		Normal Pressure (psig)	Axial Compr. Load (kips)	Average Compr. Stress (ksi)	Critical Location	Normal Pressure (psig)	Axial Compr. Load (kips)	Average Compr. Stress (ksi)	Critical Failure Mode
TT802041-1	Baseline (Straight Stiffeners)	Elastic Normal Pressure	6.4	0	0	△4	-	-	-	-
		Elastic Axial Compression	0	111.4	10.2	△4	-	-	-	-
		Elastic Combined Load △1	4.0	100.4	9.2	△4	-	-	-	-
		Elastic Combined Load △2	8.0	98.3	9.0	△4	-	-	-	-
		Combined Load to Failure △3	10.4	68.6	6.3	△4	33.0	224.4	20.5	△8
TT802041-1B	Baseline (Straight Stiffeners)	Axial Compression to Failure	-	-	-	-	0	223.5	20.4	△9
TT802041-3	Stiffeners prebowed 3/8 in.	Elastic Normal Pressure	10.2	0	0	△4	-	-	-	-
		Elastic Axial Compression	0	68.9	6.4	△5	-	-	-	-
		Elastic Combined Load △1	4.0	64.6	6.0	△4	-	-	-	-
		Elastic Combined Load △2	8.0	43.1	4.0	△4	-	-	-	-
TT802041-3 Mod.	Stiffeners prebowed 3/16 in.	Elastic Normal Pressure	12.1	0	0	△4	-	-	-	-
		Elastic Axial Compression	0	75.4	7.0	△5	-	-	-	-
		Elastic Combined Load △1	4.0	130.3	12.1	△7	-	-	-	-
		Elastic Combined Load △2	8.0	115.2	10.7	△6	-	-	-	-
		Combined Load to Failure △3	12.7	82.7	7.7	△4	33.0	214.8	19.9	△8
TT802041-3A Mod.	Stiffeners prebowed 3/16 in.	Elastic Normal Pressure	6.0	0	0	△4	-	-	-	-
		Axial Compression to Failure	6.0	-	-	△7	0	221.6	29.9	△

NOTES:
△1 Normal pressure held constant at 4 psig.
△2 Normal pressure held constant at 8 psig.
△3 Normal pressure proportional to axial load.
△4 Stiffener free edge at frame penetration.
△5 Deck plate bending over frame.
△6 Stiffener free edge at mid-span of center bay.
△7 Deck plate at mid-span of center bay.
△8 Deck plate buckling at mid-span of center bay with stiffener crippling at frame penetrations.
△9 Deck plate buckling and stiffener crippling at mid-span of center bay.

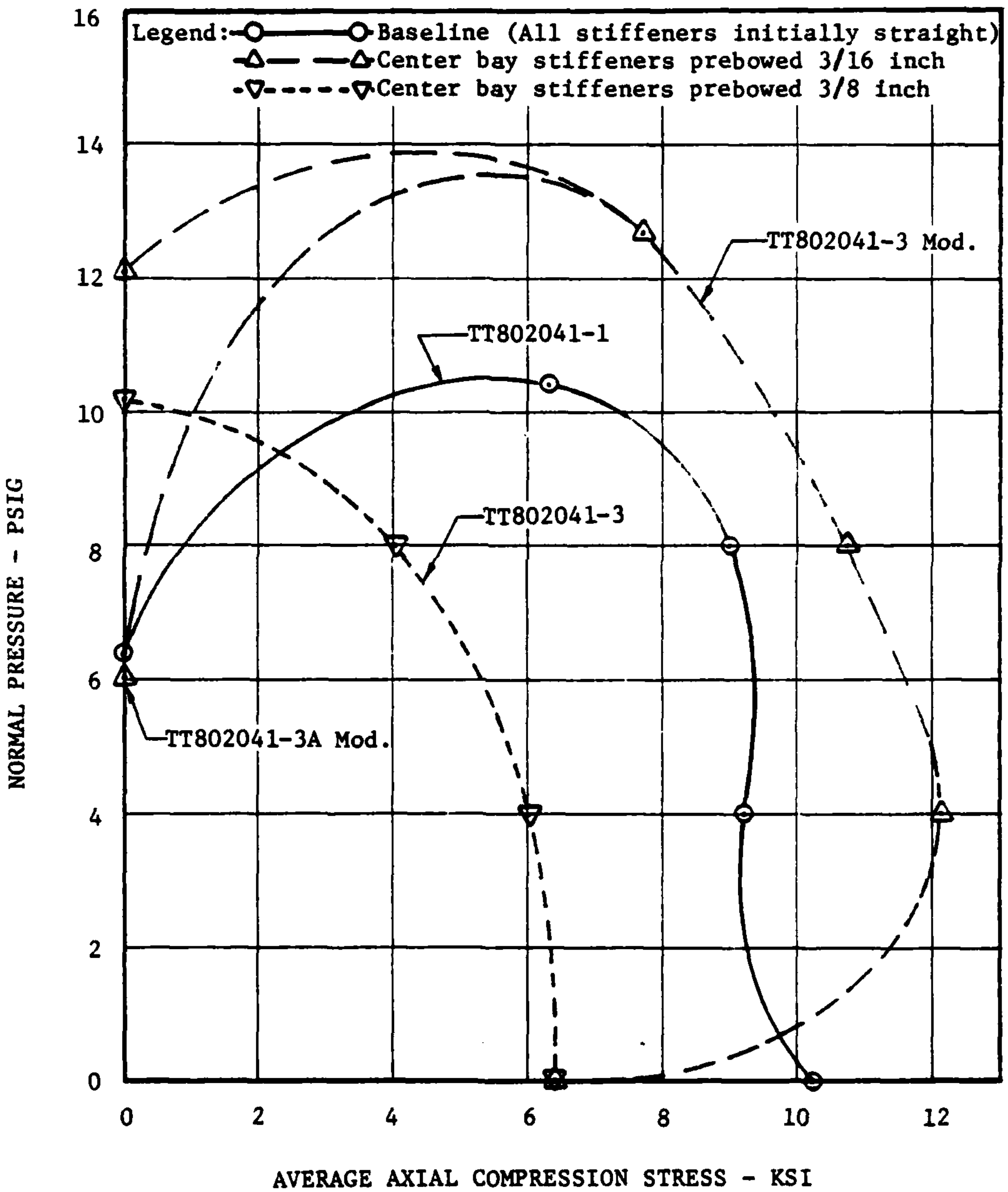


Figure 7-14. Elastic Limit Test Interaction Curves for Three-Bay Panel Element Test Specimens.

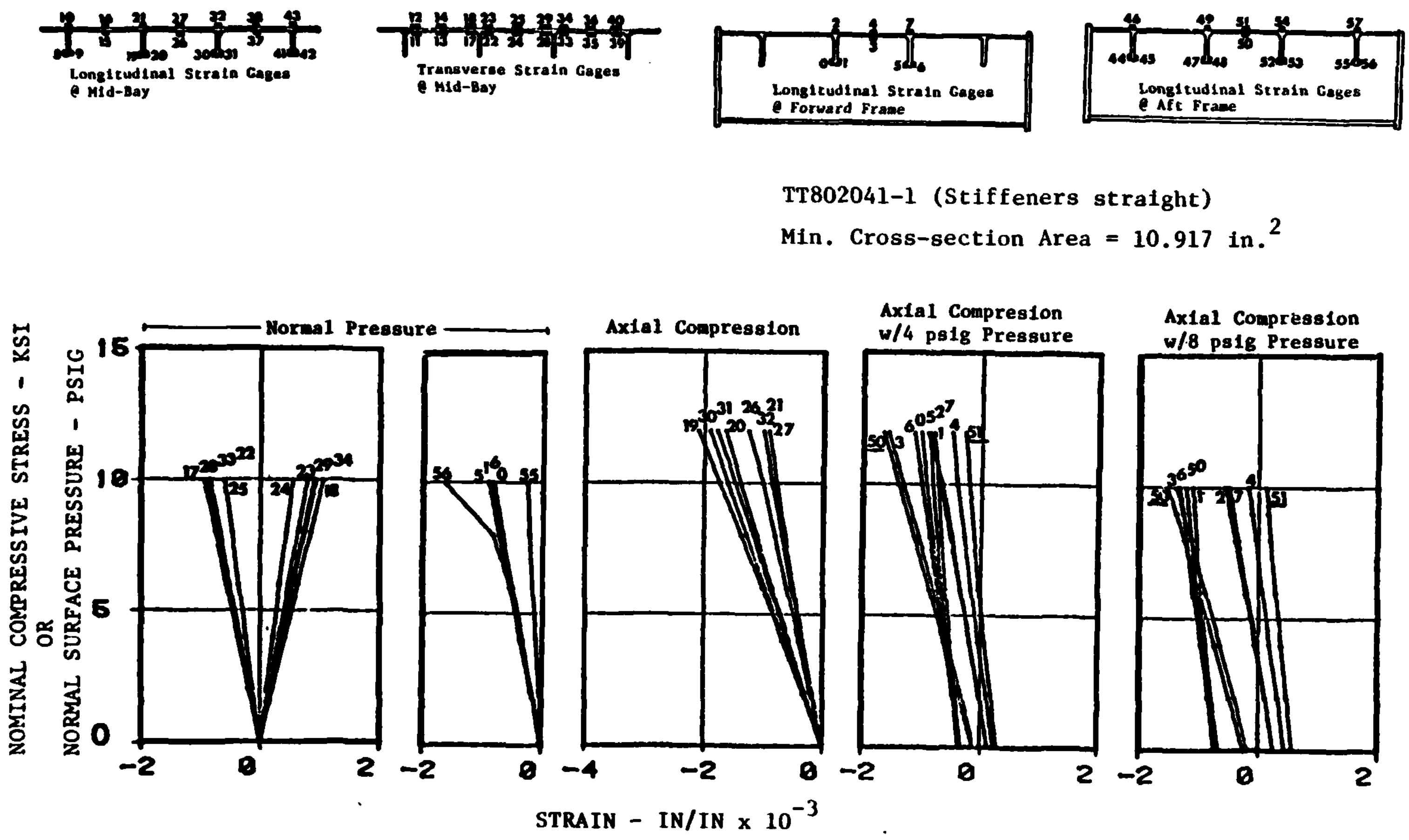


Figure 7-15. Strain Plots for Three-Bay Element No. TT802041-1, Elastic Test Conditions.

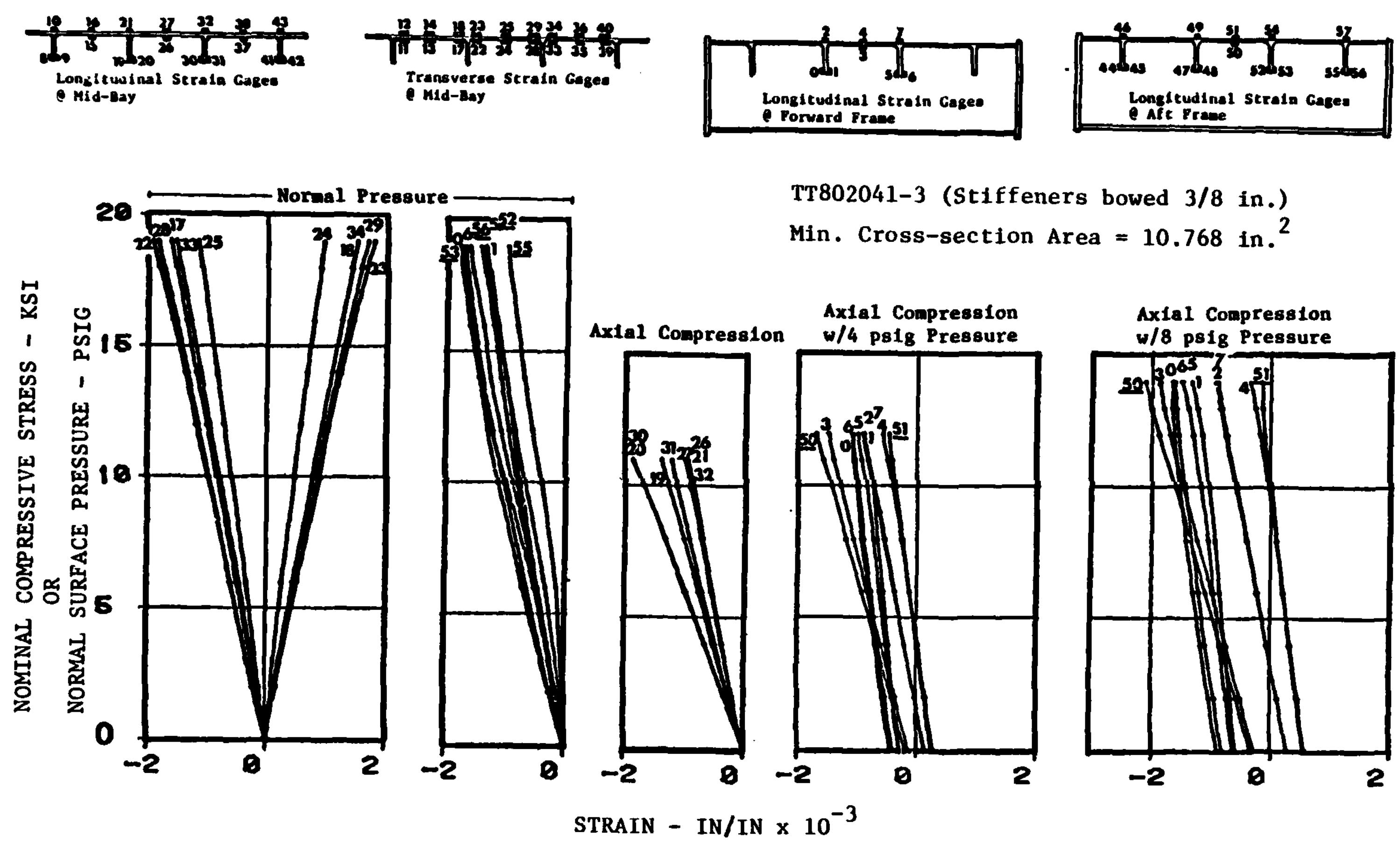


Figure 7-16. Strain Plots for Three-Bay Element No. TT802041-3, Elastic Test Conditions.

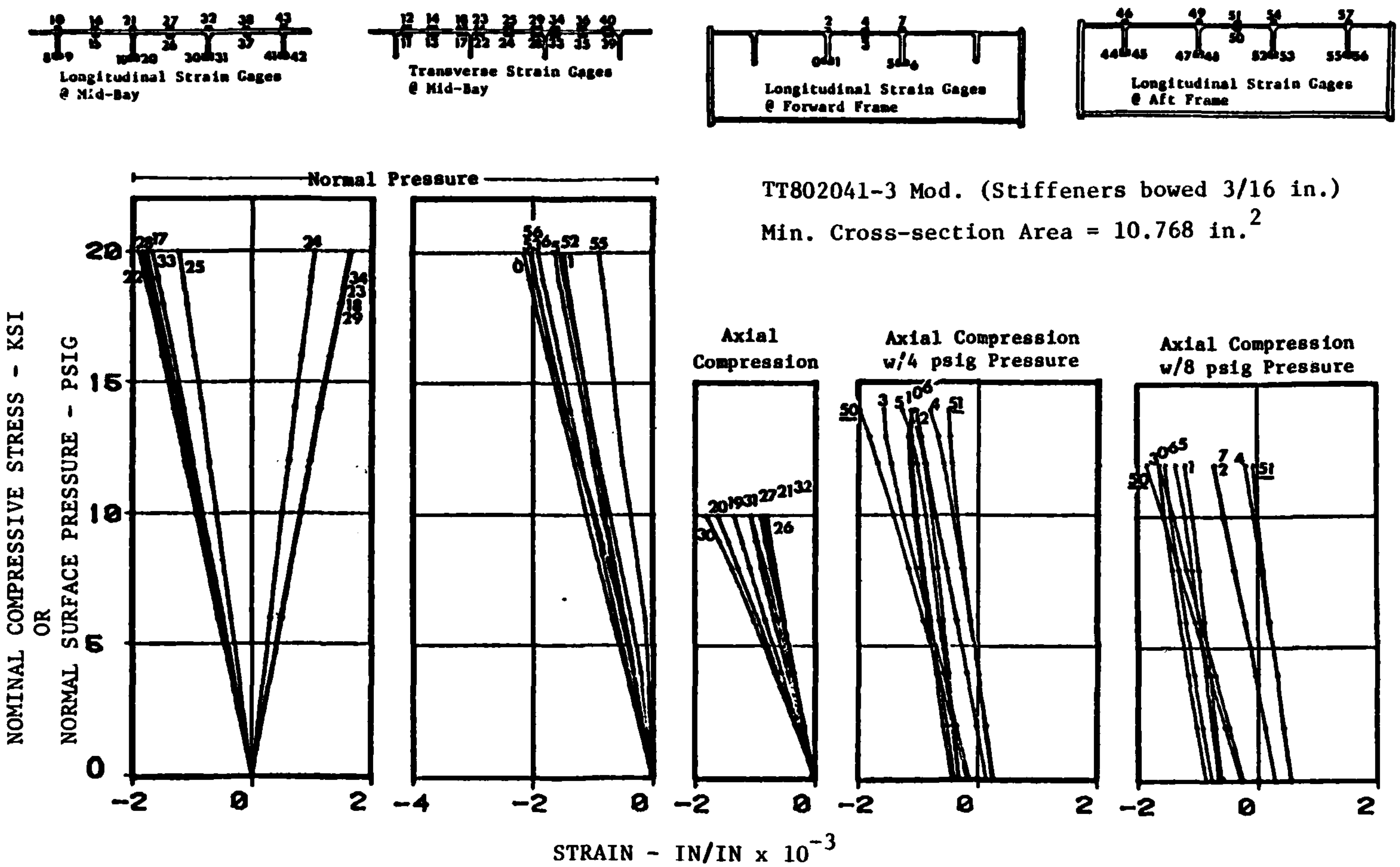
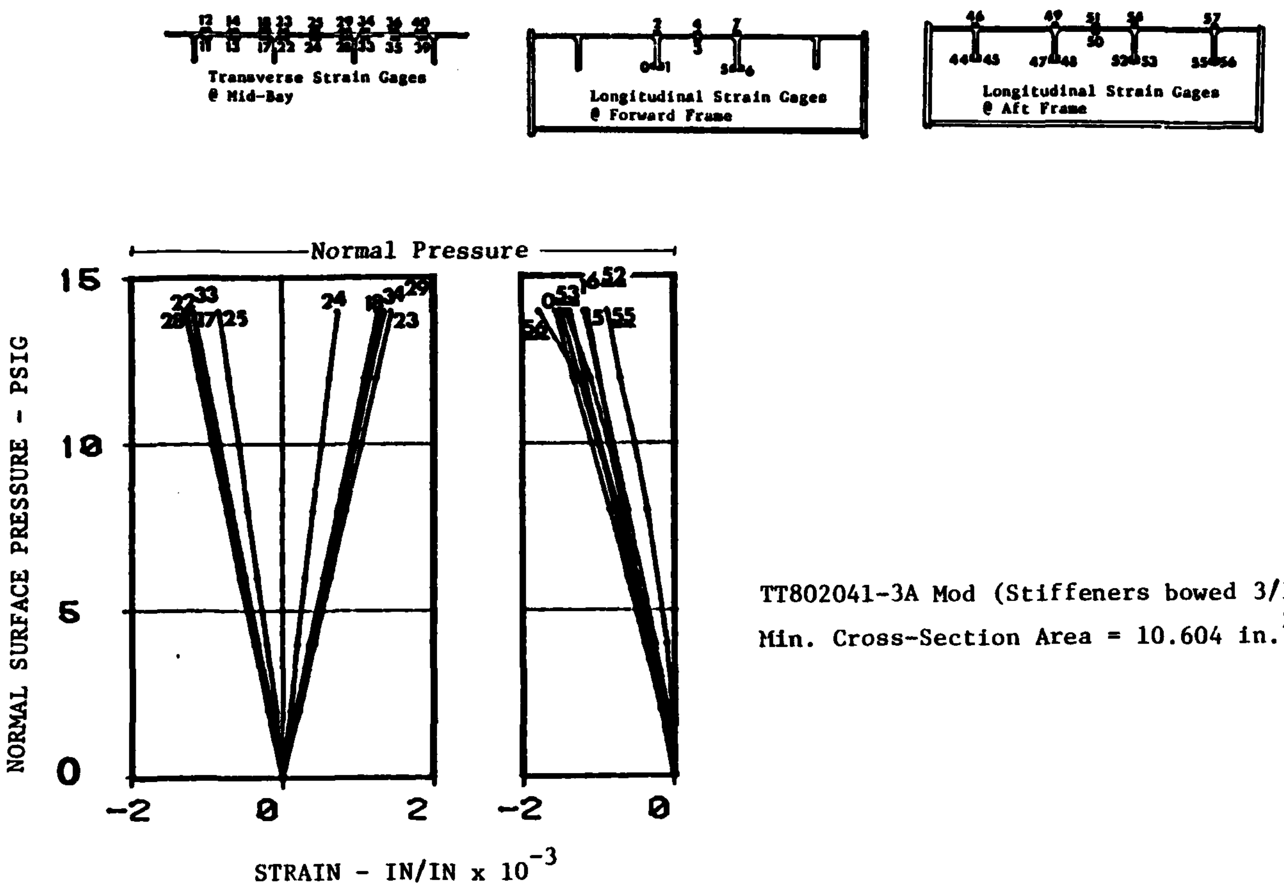


Figure 7-17. Strain Plots for Three-Bay Element No. TT802041-3 Mod, Elastic Test Conditions.



TT802041-3A Mod (Stiffeners bowed 3/16 in.)

Min. Cross-Section Area = 10.604 $in.^2$

Figure 7-18. Strain Plots for Three-Bay Element No. TT80204-3A Mod, Normal Pressure Elastic Test.

Comparison of the three-bay element ultimate failure loads to the elastic limit interaction curves is graphically depicted in Figure 7-19.

Figure 7-20 presents the recorder plots of applied axial load versus axial displacement for each of the four tests to failure. These curves exhibit a relatively sharp decline in load-carrying capability after failure occurred in specimens subjected to combined axial compression and normal pressure loadings. For the tests conducted with axial compression only, no such decline was observed for the same specimen axial displacement.

Plots of the more significant measured strains versus nominal axial compressive stress for each of the three-bay element specimens tested to failure are presented in Figures 7-21 through 7-24.

Photographs of the four three-bay element specimens after the tests to failure are presented in Figures 7-25 through 7-28. These photographs illustrate the specimen failure modes including the plate buckling and the stiffener bulkling and crippling patterns.

During the tests to failure, waviness of the plate was the initial instability mode observed in all cases. As the axial loading was increased, stiffener buckling became evident. Regardless of whether the stiffener was initially prebowed or not, the initial observed stiffener buckling in each bay formed three half-waves. This buckling pattern is clearly evident in the nearest bay shown in Figure 7-26(c). The final failure mode for the tests conducted with combined axial compression and normal pressure loading was stiffener crippling adjacent to the frame penetrations as shown in Figures 7-25 and 7-27. The ultimate failure mode for the tests conducted with axial compression loading only was stiffener crippling at the mid span of the center bay as shown in Figures 7-26 and 7-28.

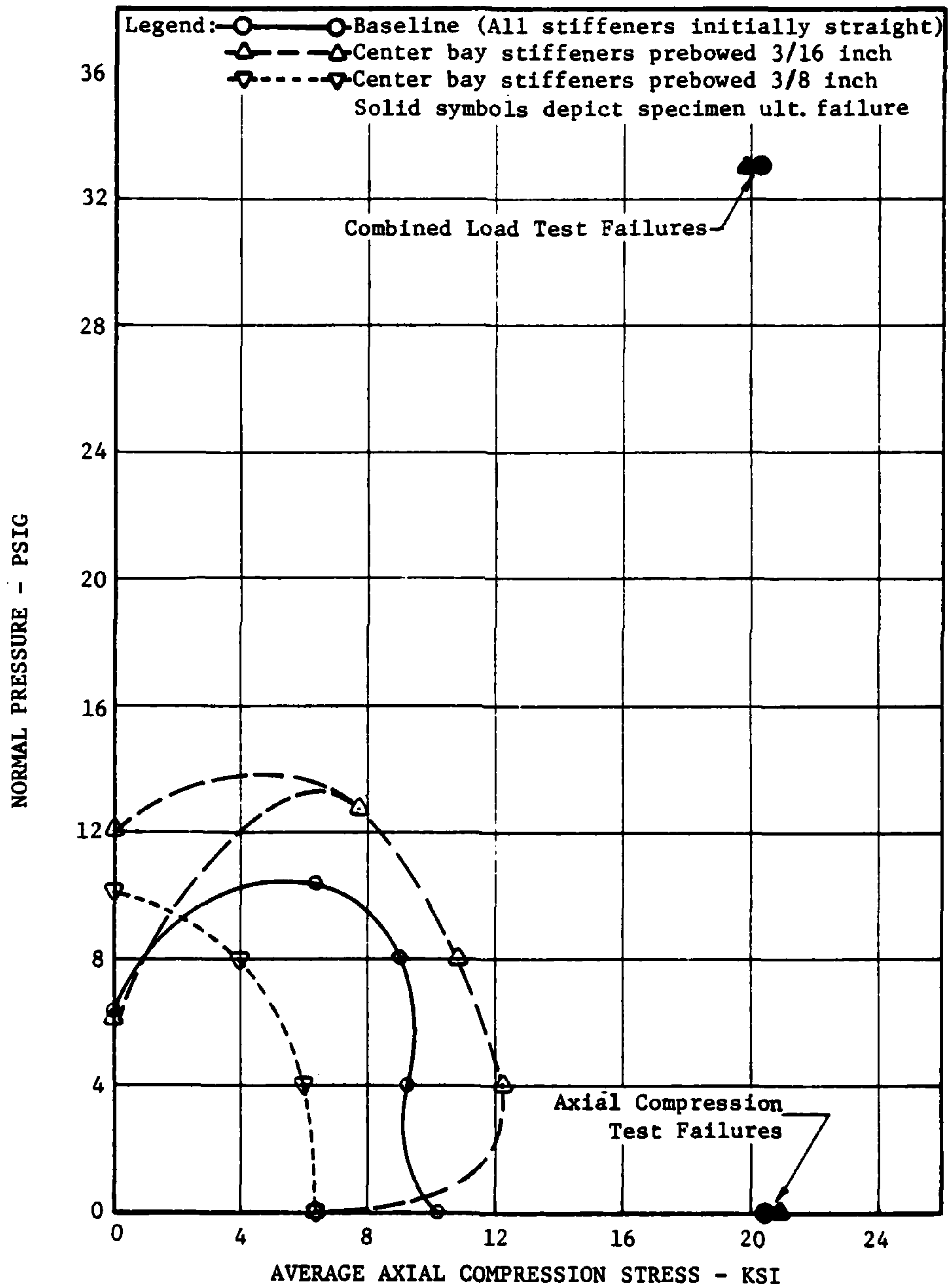


Figure 7-19. Comparison of Elastic Limits and Ultimate Failures for Three-Bay Panel Element Test Specimens.

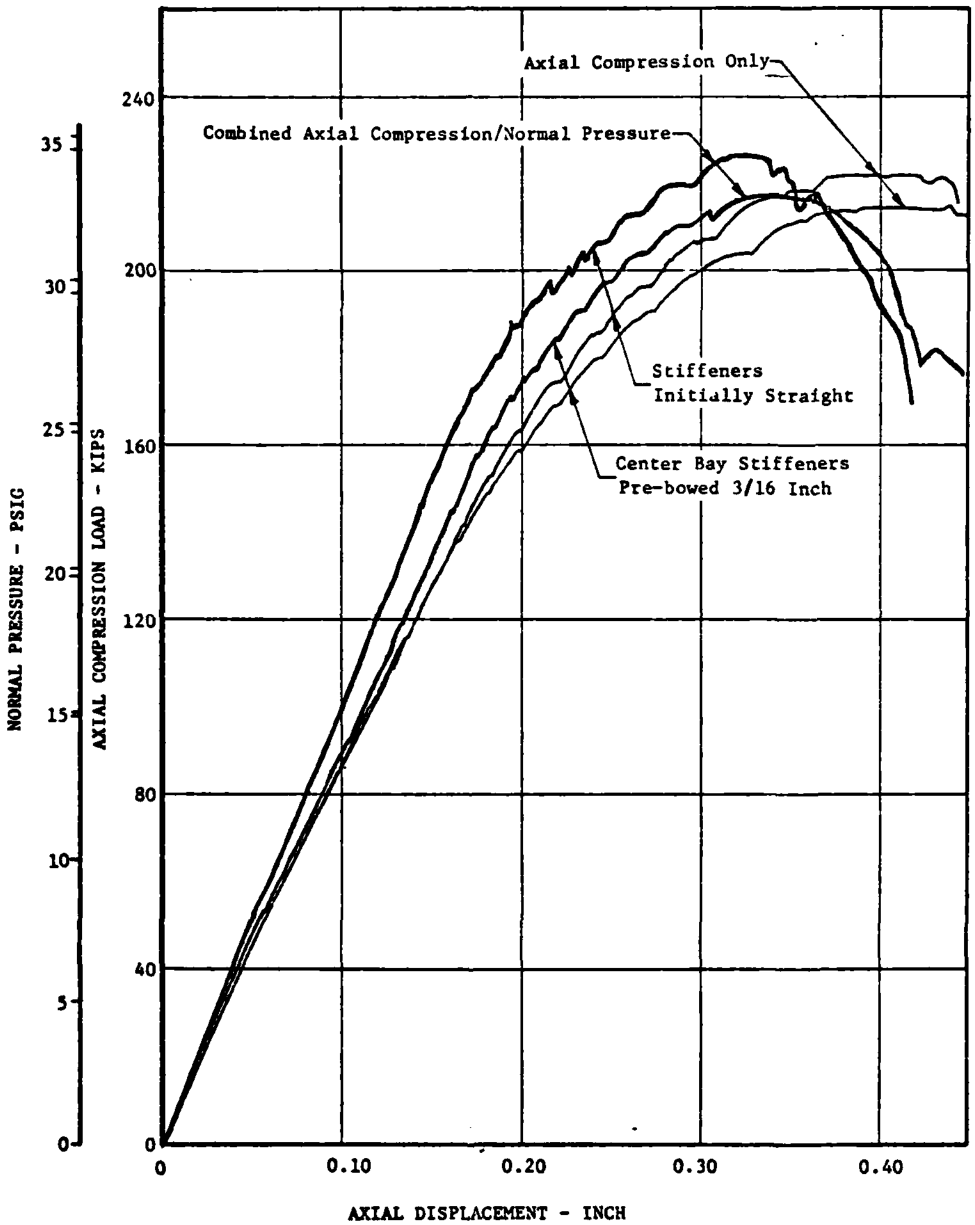
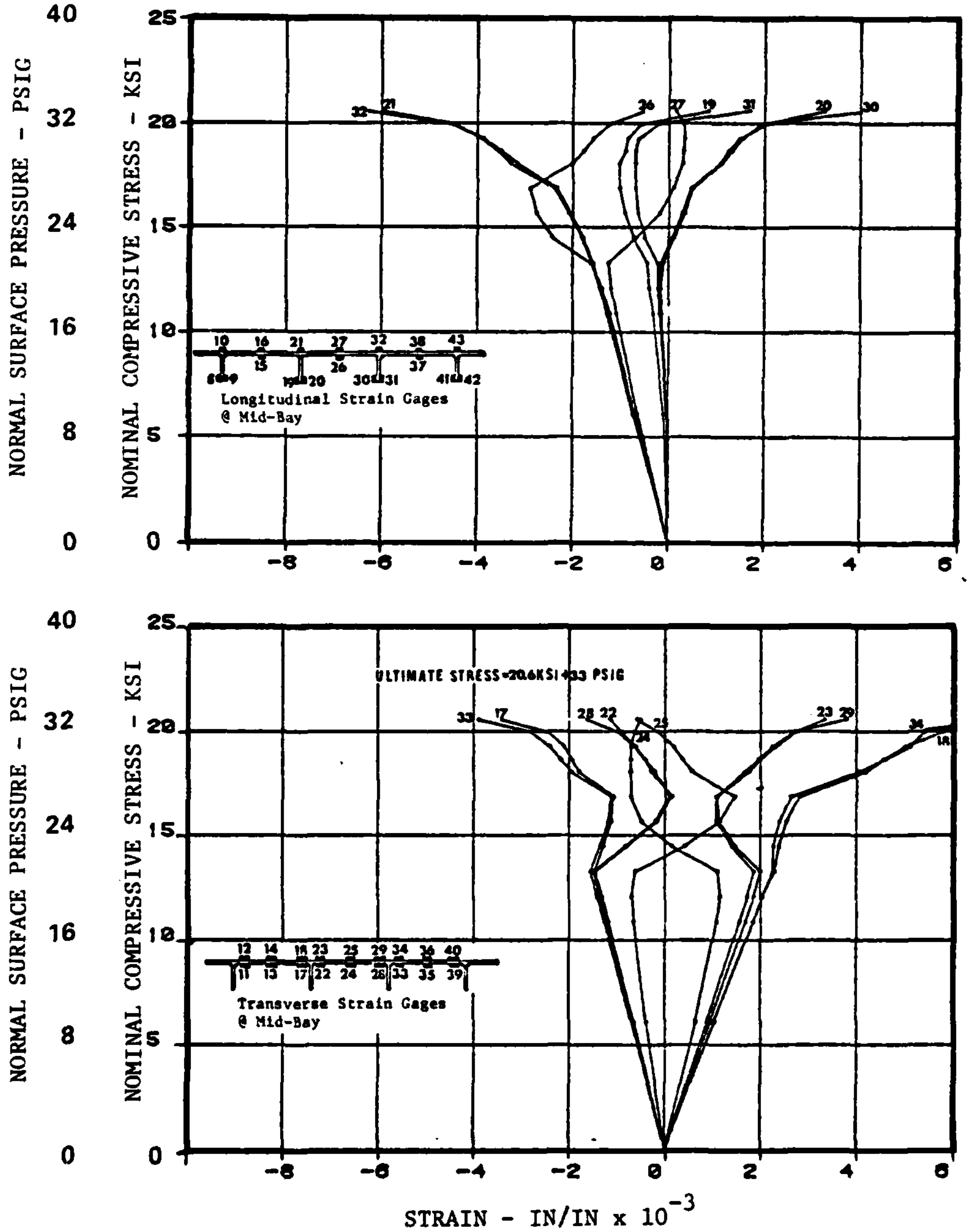
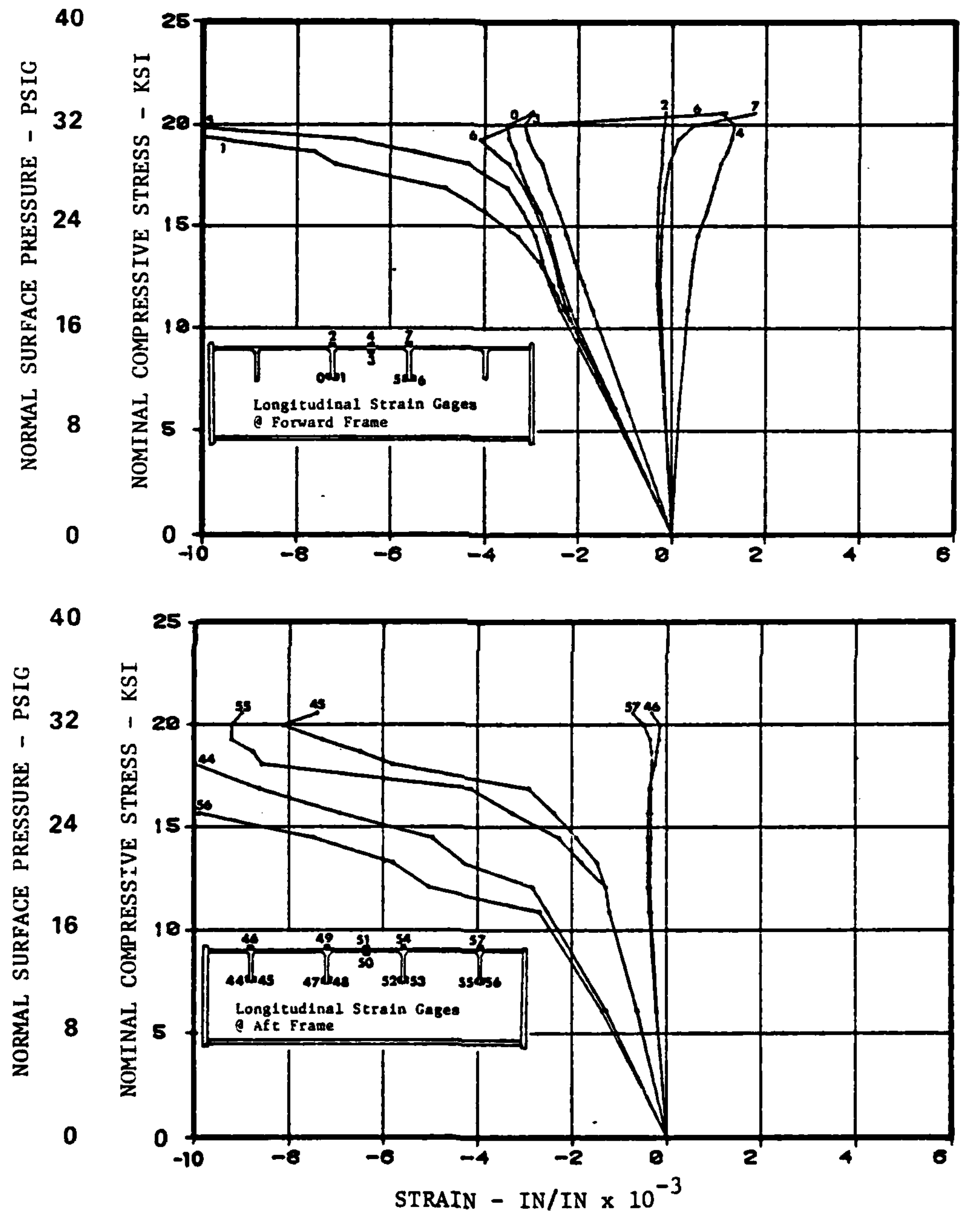


Figure 7-20. Applied Load Versus Axial Displacement Curves - Three-Bay Panel Element Tests to Failure.



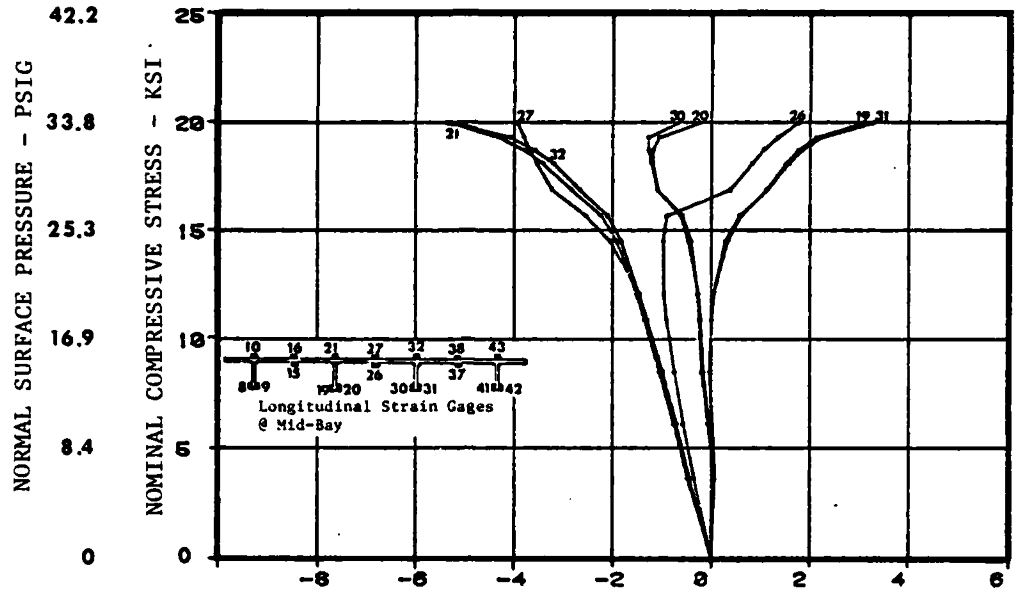
TT802041-1 (Stiffeners straight) Min. Cross-section Area = 10.917 in.^{2}

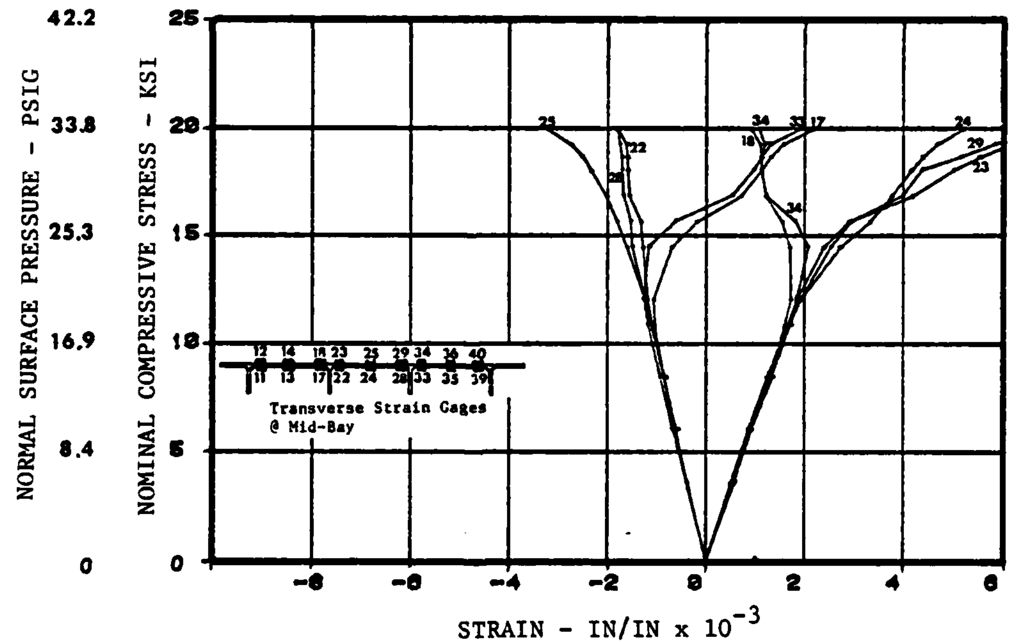
Figure 7-21. Strain Plots for Three-Bay Element No. TT802041-1, Proportional Axial Load and Normal Pressure Test to Failure, (Page 1 of 2).



TT802041-1 (Stiffeners straight) Min. Cross-section Area = 10.917 in.^{2}

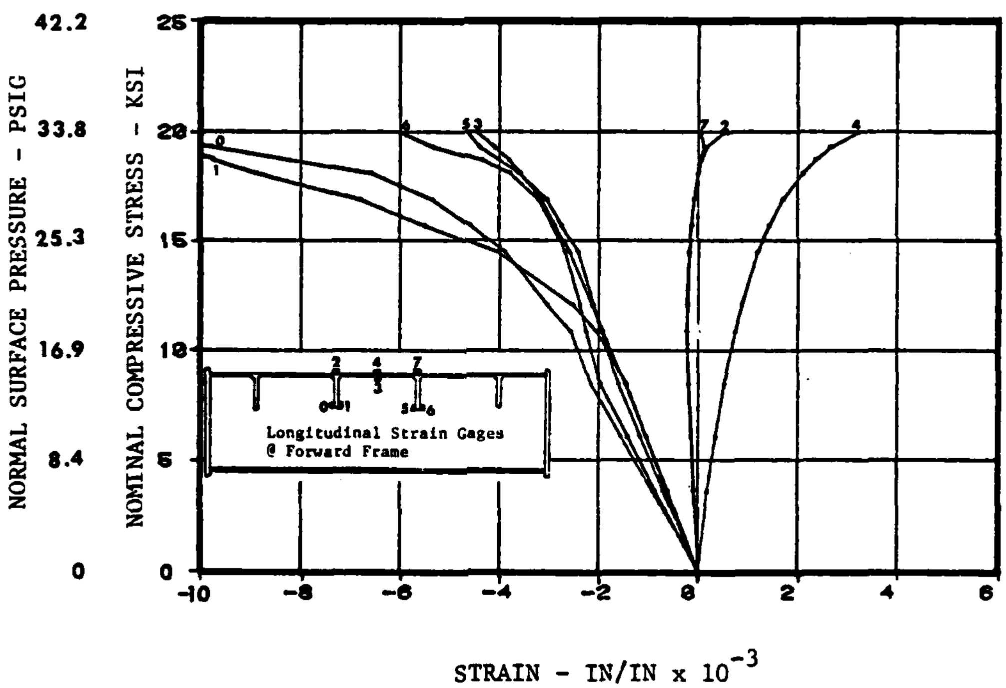
Figure 7-21. Strain Plots for Three-Bay Element No. TT802041-1, Proportional Axial Load and Normal Pressure Test to Failure, (Page 2 of 2).





TT802041-3 Mod. (Stiff. bowed 3/16 in.) Min. Cross-section Area = 10.768 in.^{2}

Figure 7-22. Strain Plots for Three-Bay Element No. TT802041-3 Mod, Proportional Axial Load and Normal Pressure Test to Failure, (Page 1 of 2).



TT802041-3 Mod. (Stiffeners bowed 3/16 in.)

Min. Cross-section Area = 10.768 in.^{2}

Figure 7-22. Strain Plots for Three-Bay Element No. TT802041-3 Mod, Proportional Axial Load and Normal Pressure Test to Failure, (Page 2 of 2)

TT802041-1B (Stiffeners straight)

Min. Cross-section Area = 10.968 in.^{2}

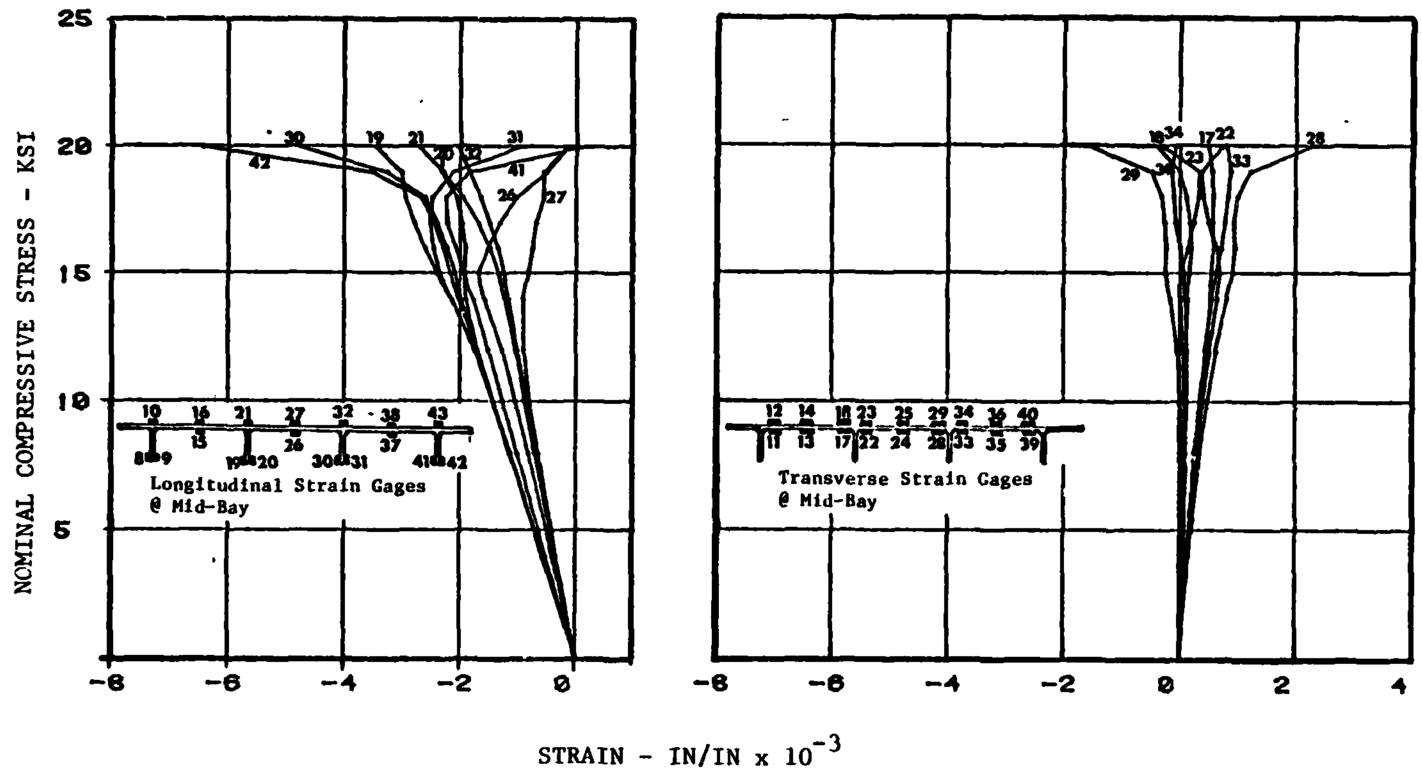


Figure 7-23. Strain Plots for Three-Bay Element No. TT802041-1B, Axial Compression Test to Failure (Page 1 of 2).

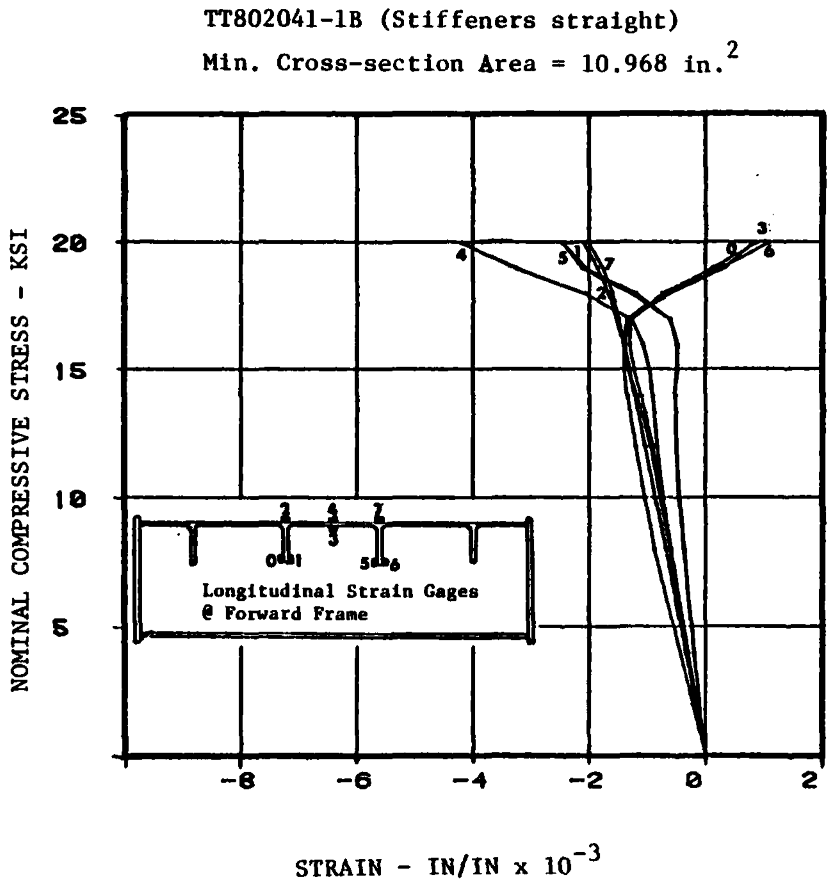
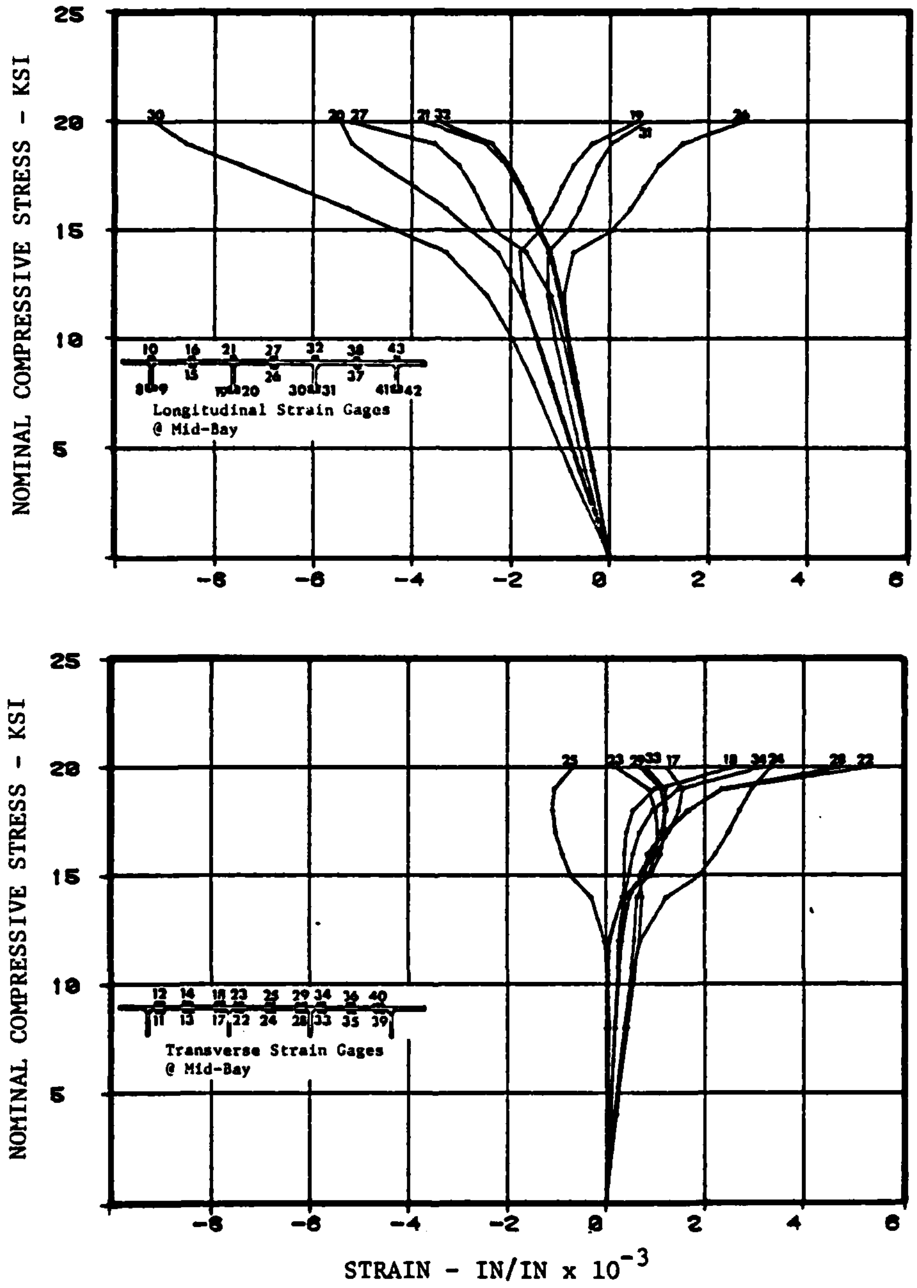
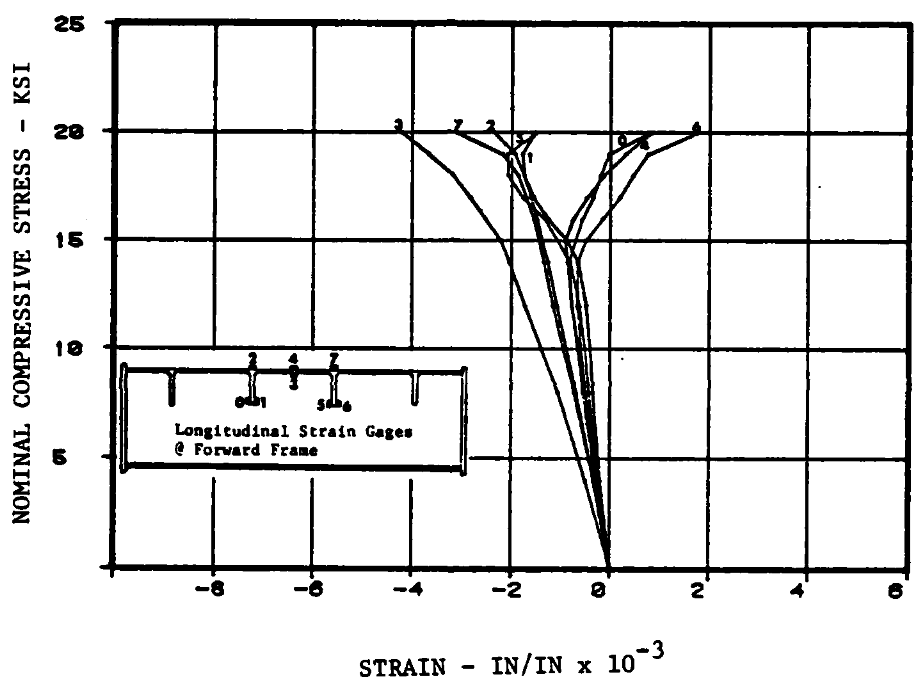


Figure 7-23. Strain Plots for Three-Bay Element No. TT802041-1B, Axial Compression Test to Failure (Page 2 of 2).



TT802041-3AMod. (Stiff. bowed 3/16 in.) Min. Cross-section Area = 10.604 in.^{2}

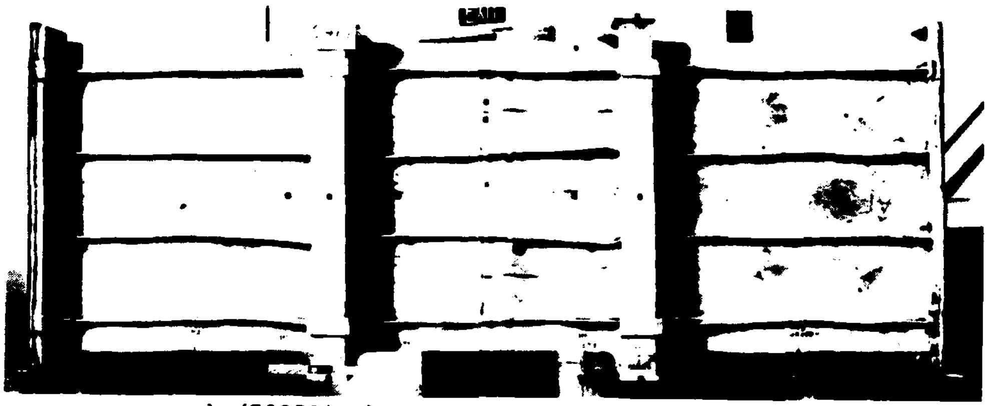
Figure 7-24. Strain Plots for Three-Bay Element No. TT802041-3A Mod, Axial Compression Test to Failure (Page 1 of 2).



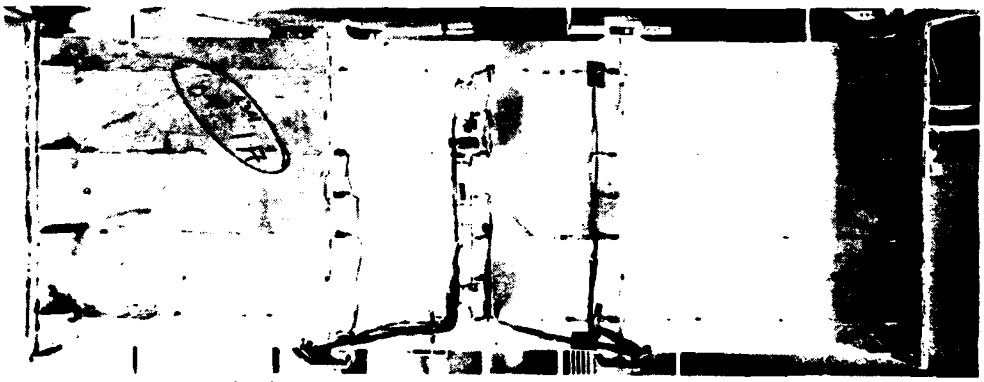
TT802041-3A Mod. (Stiffeners bowed 3/16 in.)

Min. Cross-section Area = 10.604 in.^{2}

Figure 7-24. Strain Plots for Three-Bay Element No. TT802041-3A Mod, Axial Compression Test to Failure (Page 2 of 2).

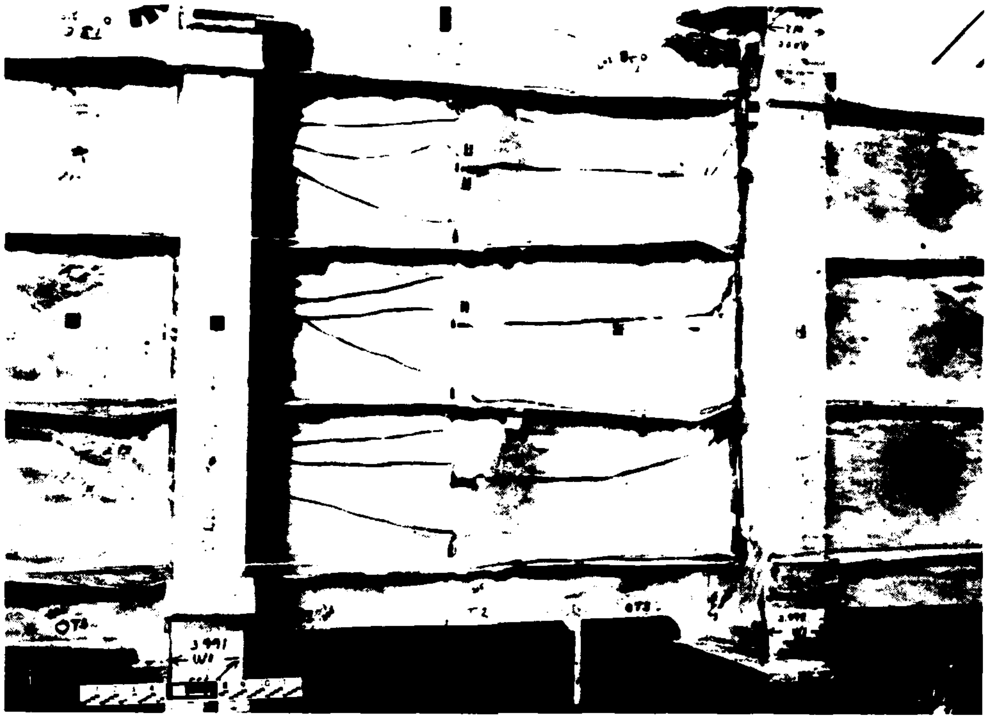


a) (790594-1) Stiffener Side Overall View.



b) (790594-2) Plate Side Overall View.

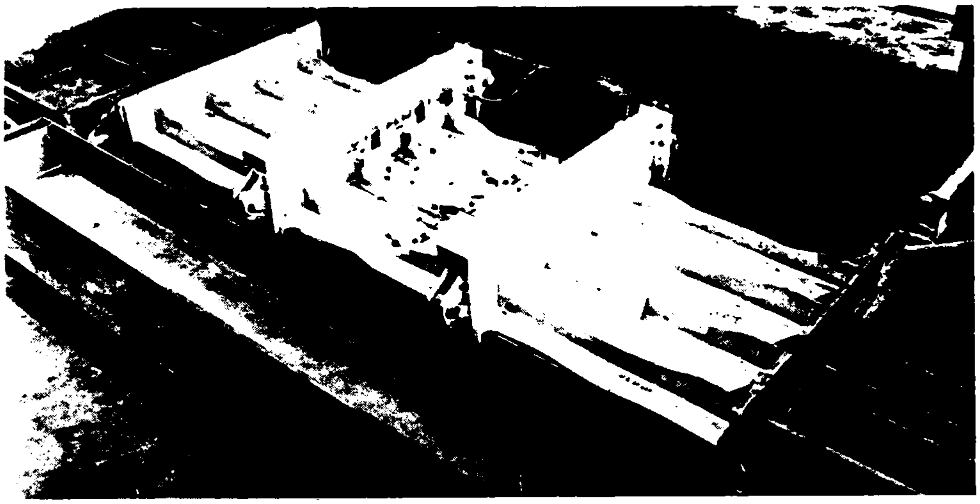
Figure 7-25. Three-Bay Element Specimen No. TT802041-1 (All Stiffeners Initially Straight) After Combines Axial Compression/ Normal Pressure Test to Failure. (Sheet 1 of 2)



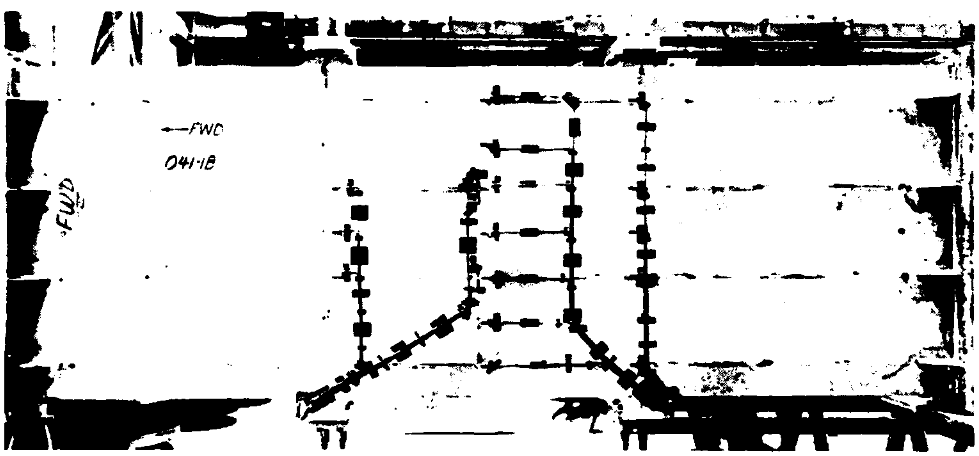
c) (790594-12 Center Bay Detail View.

d) (790594-11) Center Bay Oblique View.

Figure 7-25. Three-Bay Element Specimen No. TT802041-041-1 After Combined Axial Compression/Normal Pressure Test to Failure. (Sheet 2 of 2)

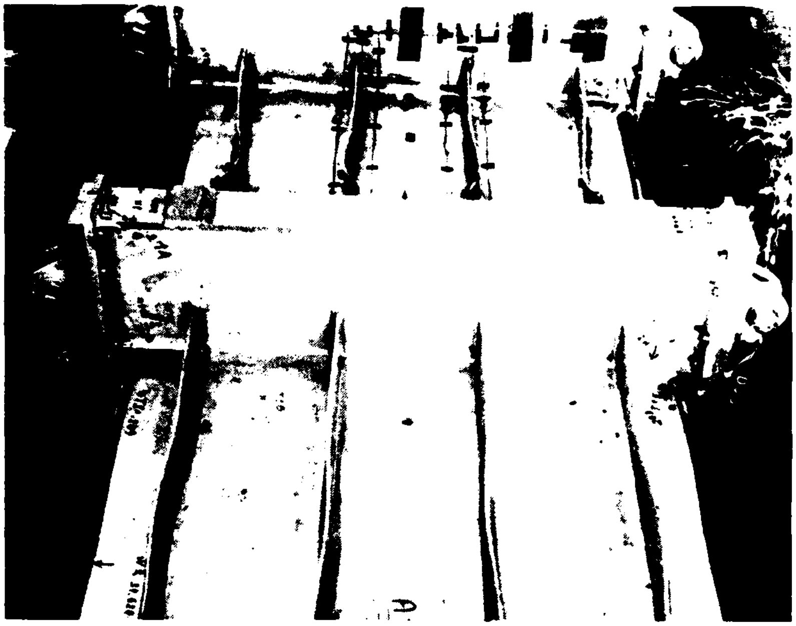


a) (790791-4) Stiffener Side Overall View with Approximately 105,000 Pounds Residual Axial Compression Load Applied to Specimen.

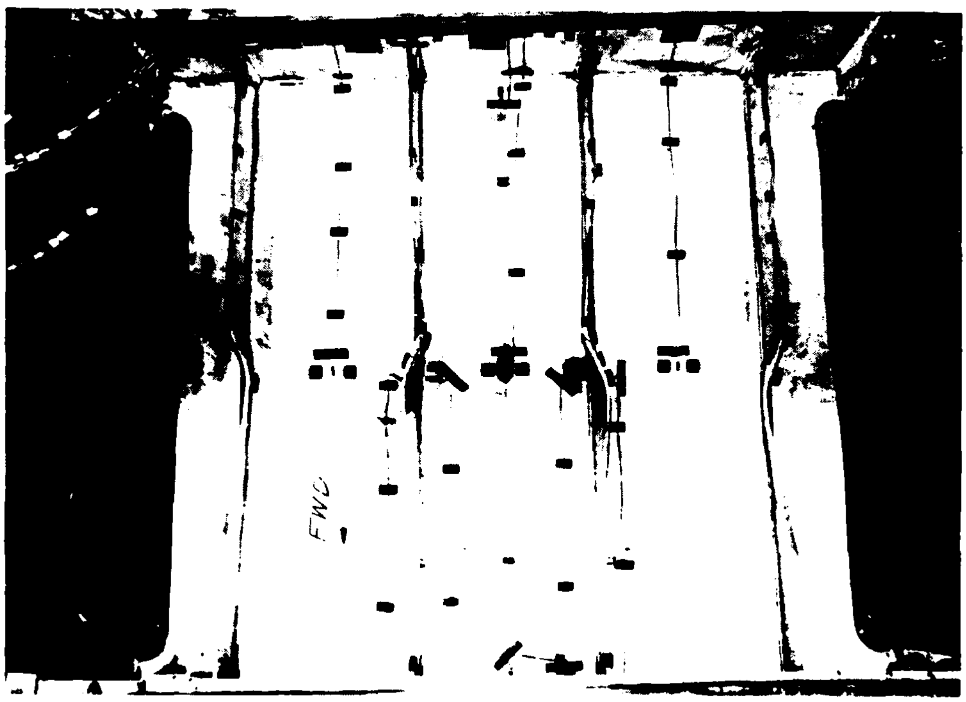


b) (790833-1) Plate Side Overall View.

Figure 7-26. Three-Bay Element Specimen No. TT802041-1B (All Stiffeners Initially Straight) After Axial Compression Test to Failure. (Sheet 1 of 2)

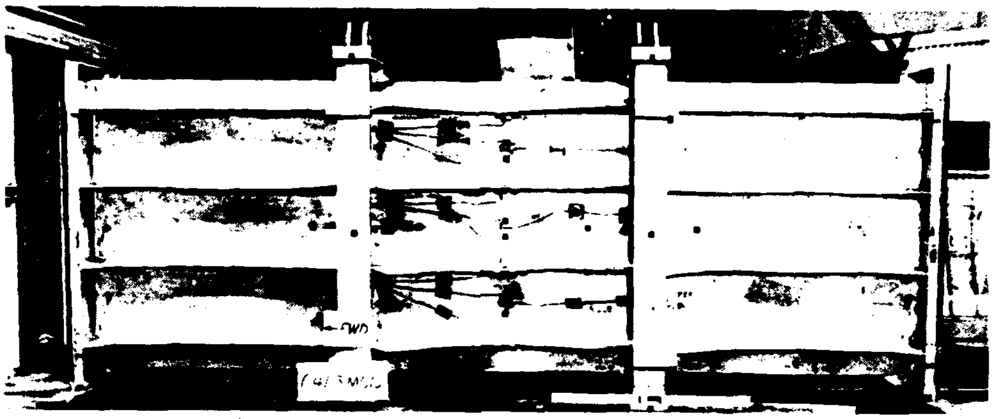


c) (790791-1) Aft End View Illustrating Stiffener Buckling Patterns Under 105,000 Pounds Residual Compression Load.

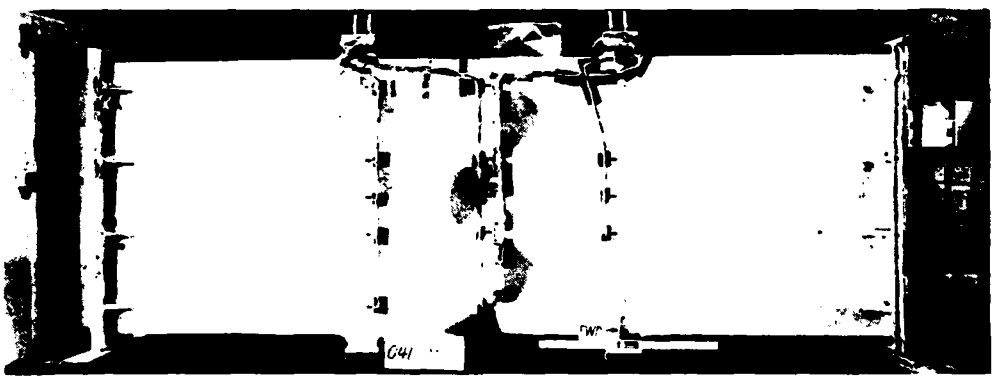


d) (790791-3) Detail View of Center Bay (105,000 Pounds Residual Compressive Load).

Figure 7-26. Three-Bay Element Specimen No. TT802041-1B After Axial Compression Test to Failure. (Sheet 2 of 2)



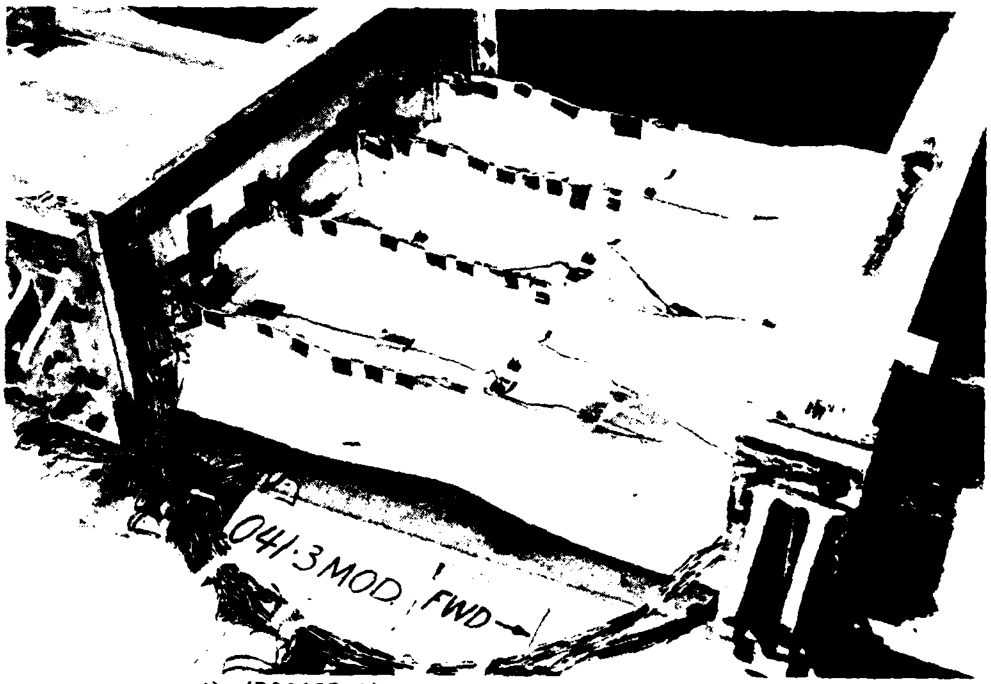
a) (790657-2) Stiffener Side Overall View



b) (790657-4) Plate Side Overall View

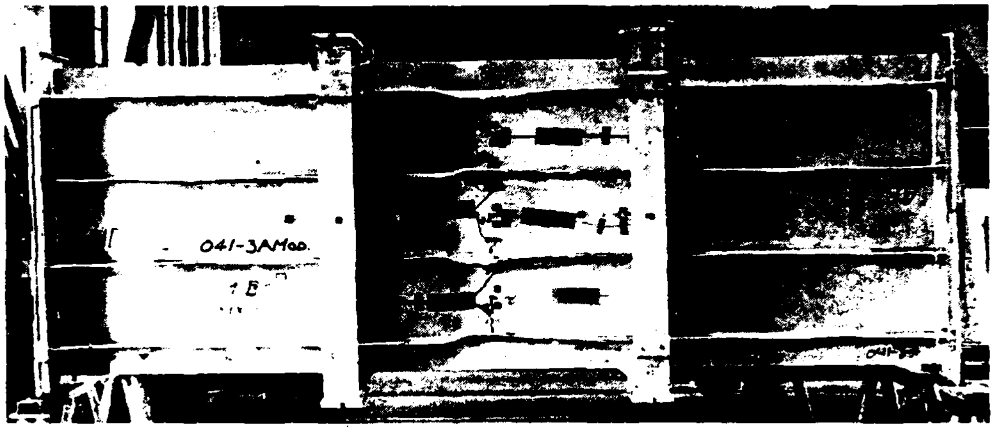
Figure 7-27. Three-Bay Element Specimen No. TT802041-3 Mod. (All Center Bay Stiffeners Prebowed 3/16 Jack) After Combined Axial Compression/Normal Pressure Test to Failure. (Sheet 1 of 2)

c) (790657-6) Center Bay Axial View.

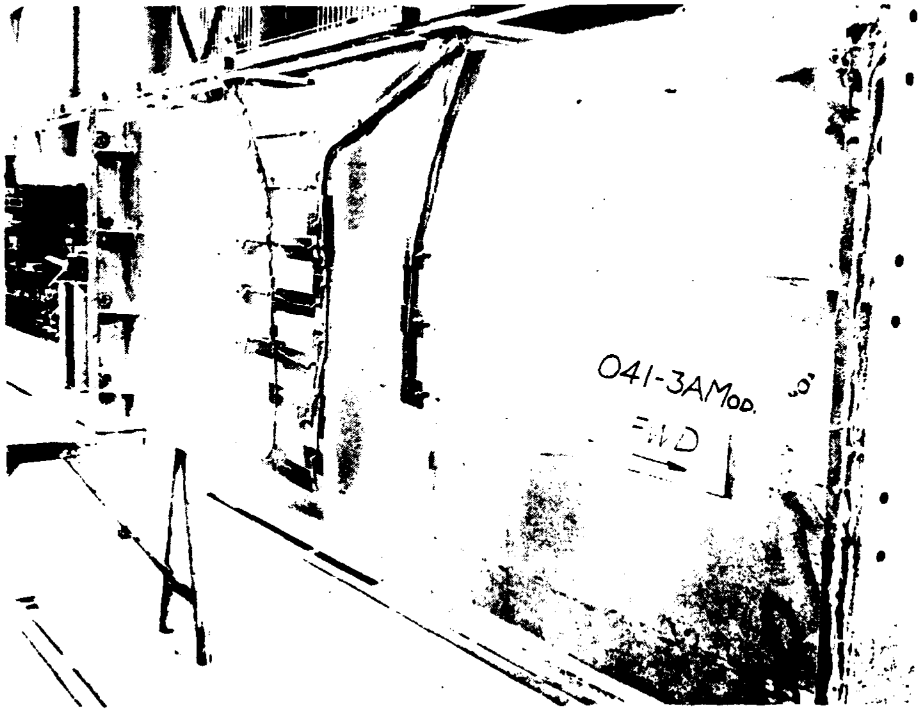


d) (790657-1) Center Bay Oblique View.

Figure 7-27. Three-Bay Element Specimen No. TT802041-3 Mod. After Combined Axial Compression/Normal Pressure Test to Failure. (Sheet 2 of 2)



a) (790792-3) Stiffener Side Overall View.



b) (790792-4) Plate Side Overall View.

Figure 7-28. Three-Bay Element Specimen No. TT802041-3A Mod. (All Center Bay Stiffeners Prebowed 3/16 Inch) After Axial Compression Test to Failure.

7.8 CORRELATION ANALYSIS OF THREE-BAY PANEL ELEMENT TEST DATA -- The data obtained from the three-bay panel test are evaluated in order to compare the test results with the elastic structural hevarior predicted by analytical solutions. The interprotation of test data together with sample calculations will be presented. The detailed discussions will be concentrated toward the verification of the test results inconjunction with the analytical methods and assumptions. Complete data obtained from strain gages and deflection indicators will be made available in the appendix.

The following various test configurations for the three-bay stiffened panels under uniformly distributed axial loading will be considered.

a. Stiffened panels with surface pressure
b. Stiffened panels without surface pressure
c. Initially straight stiffeners
d. Prebowed stiffeners

Several areas of particular interest on the existing design strengths and the future structural optimization for the buckling and the ultimate compressive strength of stiffened plates, correlation of test results with predicted allowables using analytical methods, and conclusion and recommendation will be convered in this section.

7.8.1 BUCKLING STRENGTH OF STIFFENED PLATE -- It is difficult to determine precisely the load at the exact instant of plate buckling. This is due to several uncertainties such as initial nonflatness of the plate, local yielding in weldments, out of plane bending in the plate due to eccentric loading, mislocation strain gages. It should be noted that the plate buckling initiates before it can be detected by visual inspection.

7.8.1.1 Determination of Buckling -- Experimentally, there are two methods commonly used to determine plate buckling; the "stain reversal" and "[illegible]-of-the-knee" method.

The strain reversal technique requires a more accurate placement of strain measurements with closer mesh of data points. The state of strain reverses from compression to tension on the convex side of the surface, this indicates buckling is taking place. On the other hand, the strain of the concave side shows a sudden increase of strain rate. It is obvious that location of strain measurements are very critical, thus highly sensitive to the results. However, the strain measurements can be made coincidently with the peak buckling amplitude when the buckling mode shape is well defined, then, the "strain reversal" technique will be superior to determine the buckling load.

The nonlinear structural behavior can best be described by load versus deflection curve. The "top-of-the-knee" technique utilizes the change of compression stiffness of the plate element as a result of in-elastic behavior of an indication of load distribution within the structural elements. This precludes the buckling phenomena. The location of the "top-of-the-knee" on the load deflection curve is not always obvious. However, it is generally conservative. In this evaluation the "top-of-the-knee" method is used to establish buckling loads of various test specimens. "strain reversal" method will be used whenever verifications are required.

7.8.1.2 External Load Versus Plate Normal Deflection -- Uniformly distributed compressive load versus deflection normal to the plate for various test configurations are shown in Figures 7-29 thru 7-32. The critical plate buckling load for the case of prebowed stiffener without surface pressure is reduced by about 4% from the buckling load of initially straight stiffener configuration. This indicates that the effectiveness of edge constants of prebowed and initially straight stiffeners is not substantial. The deflection at the center of plate (deflection indicator D72) in Figure 7-30 shows an erratic behavior in comparison with the deflection measured for the plate element supported by straight stiffeners as illustrated in Figure 7-29. It can be observed from Figure 7-29 that the measurements

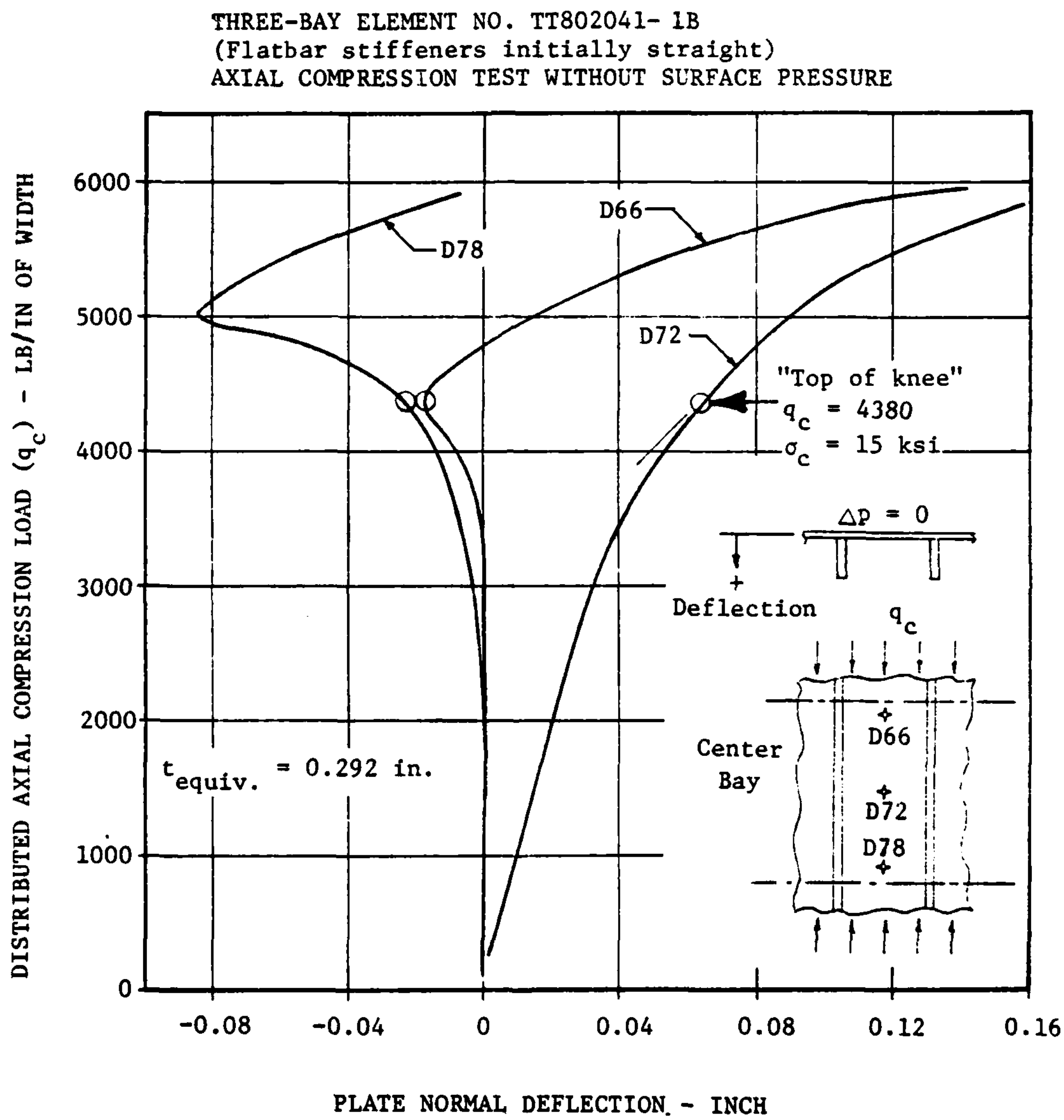


Figure 7-29. Experimental Plate Buckling Load - Element No. TT802041-1B, Axial Load Only.

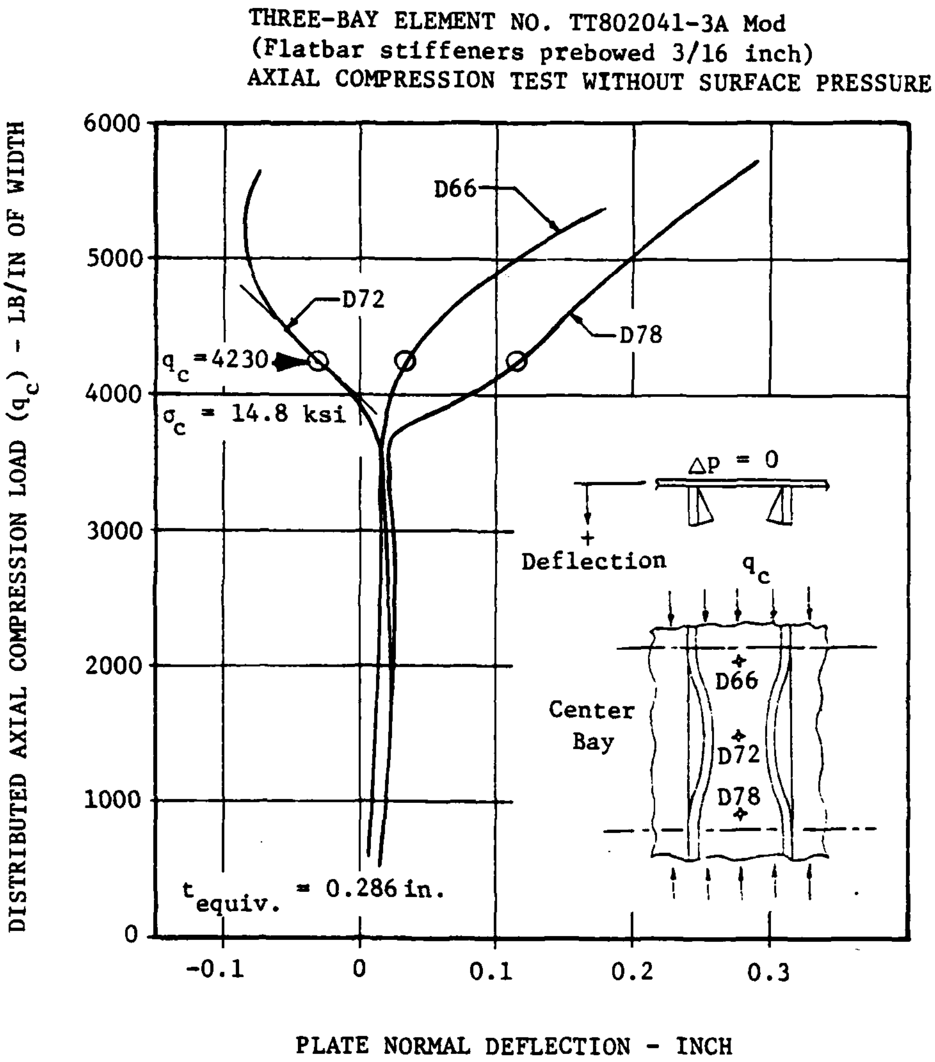


Figure 7-30. Experimental Plate Buckling Load - Element No. TT802041-3A Mod, Axial Load Only.

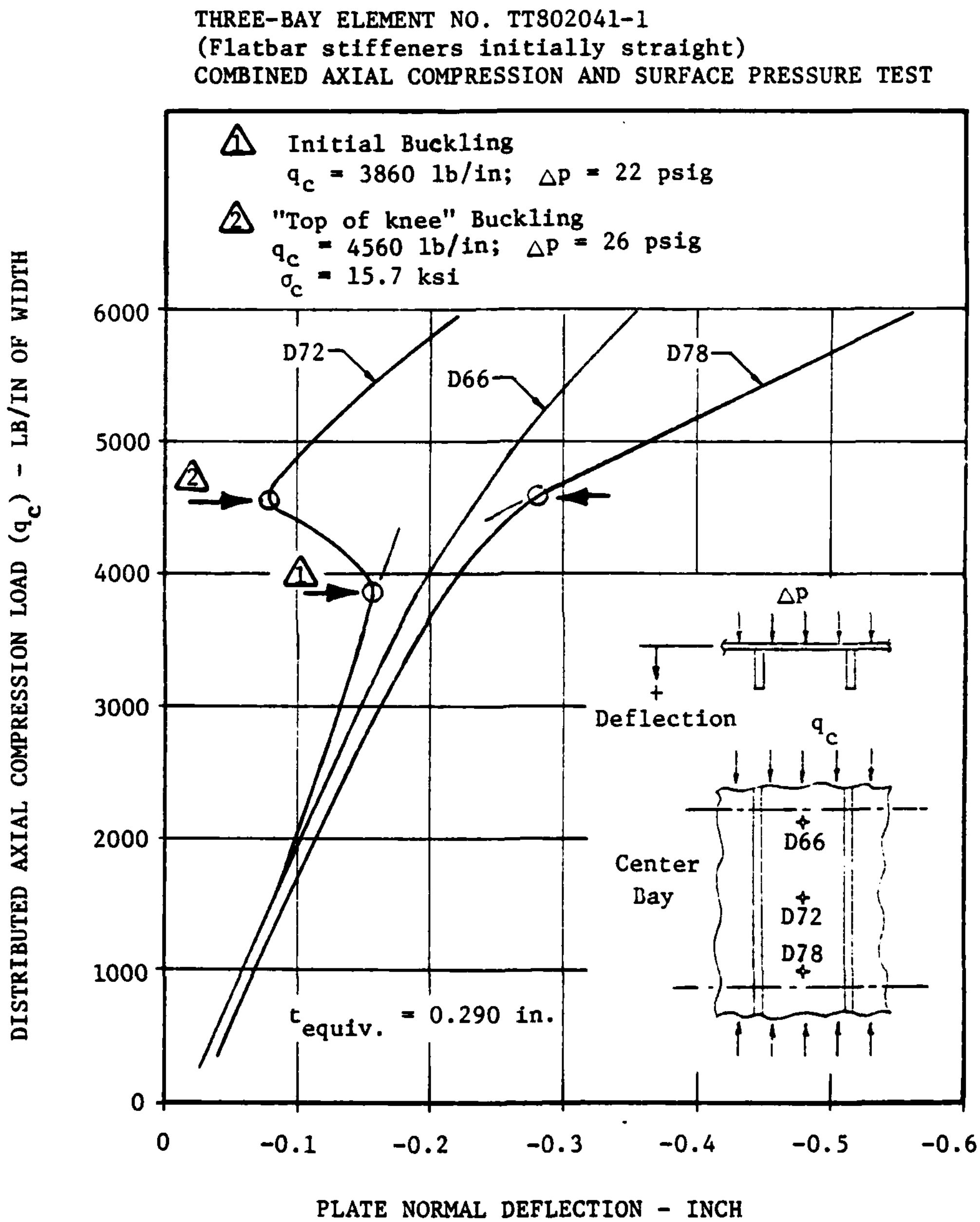


Figure 7-31. Experimental Plate Buckling Load - Element No. TT802041-1, Combined Axial Load and Surface Pressure.

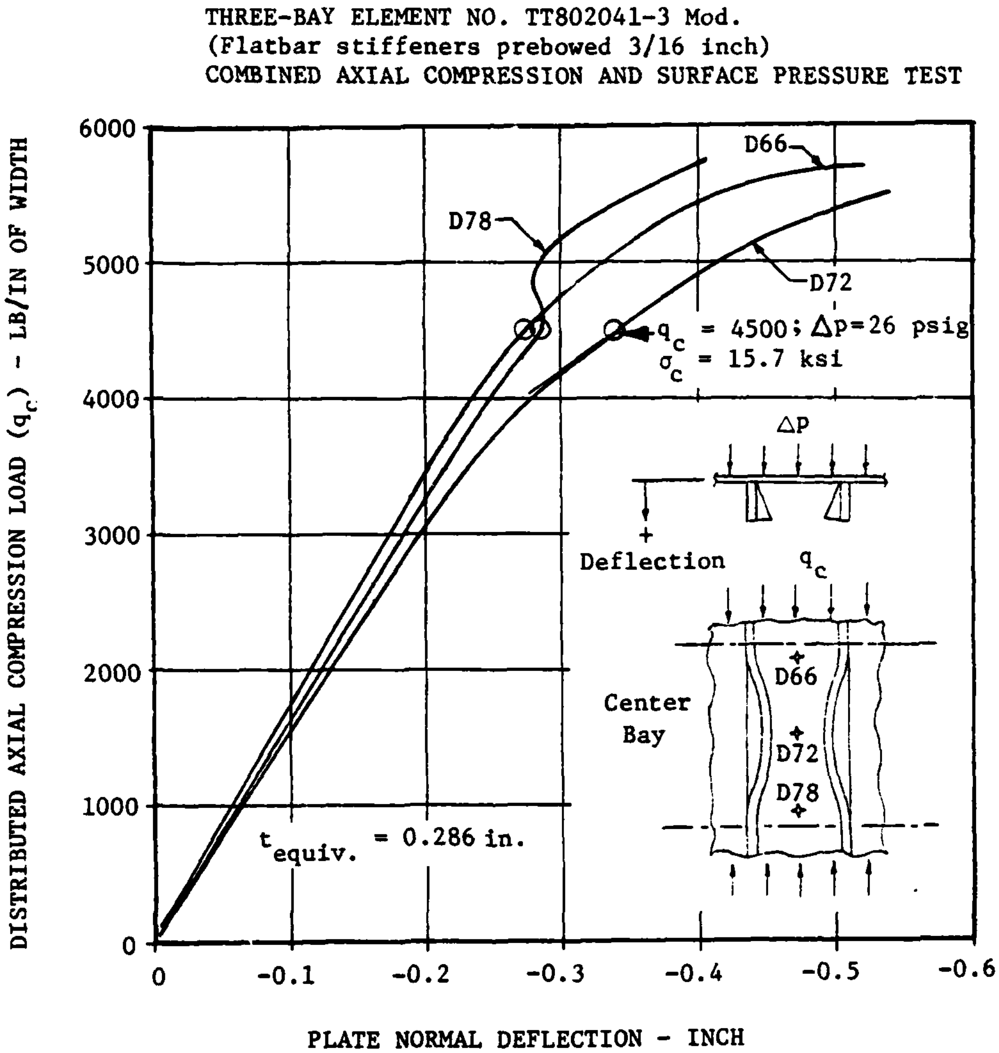


Figure 7-32. Experimental Plate Buckling Load - Element No. TT802041-3 Mod, Combined Axial Load and Surface Pressure.

for strain gage D72 exhibits a closer resemblance with the stiffeners curve for an integral structure.

7.8.1.3 Comparison of Test Results with Analytical Buckling Stress -- Theoretical plate buckling stress for simply supported panel subjected to uniformly distributed axial load is given by (for F_{cf} = 26,000 psi).

$$F_I = \frac{K \cdot \pi^2 \cdot E}{12\ (1-\mu^2)\ (K_{19})^2} \left(\frac{t_p}{b_p}\right)^2 \qquad \text{(Ref. 18, Table 6-3)}$$

where,

$$K = 3.56 \sqrt{3+(f_c/f_s})^2 \left[\sqrt{2.25 + (f_{cp}/f_s)}^2 - (f_{cp}/f_s)\right]$$

for $f_s = 0$ $\quad K = 4.0$

t_p = 0.208 inches (plate thickness)

b_p = 20.0 inches (width of plate)

E_{test} = 10.0×10^6 psi (young modulus)

K_{19} = 1 (from Figure 6-11) for $^b/a = {}^{10}/36$, $^{fs}/fp = 0$

Substituting these values into the equation

$$F_I = 4 \times \pi^2 \times 10.0 \times 10^6 \times (^{0.208}/10)^2 \quad 12\ (1-3.0333^2) = 15{,}990 \text{ psi}$$

7.8.1.4 Surface Pressure Effects on Plate Buckling Strength -- There were no noticeable effects on the stability of the stiffened plate when subjected to axial compression with surface pressure. Figures 7-31 and 7-32 shown the plate deflections for straight and prebowed stiffened panels tested under surface pressure loading. It can be observed that the stability of the plate with prebowed stiffeners is slightly improved with the aid of the surface pressure. The combined loading caused the utilization of the prebowed stiffener.

7.8.2 ULTIMATE COMPRESSIVE STRENGTH OF STIFFENED PLATE -- The buckling strength of the stiffened plate depends on various parameters such as plating thickness, aspect ratio of the individual elements, straightness of stiffeners, the effectiveness of mutual support between elements, modulus of elasticity and yield strength of each material.

The theoretical methods used to predict buckling loads for panels stiffened with flat bars are linear solutions and do not account for changes in modulus beyond the propartional limit and warped or bowed characteristics of elements. The correlation of analytical predictions and test results compares the predicted failure of the panel with the experimentally determined buckling strength located by the "top-of-the-knee" method.

7.8.2.1 Theoretical Critical Stresses -- The following sample evaluations indicate the analytical methods of failure prediction used in the 3KSES project and in the three-bay panel element tests.

Column buckling allowable - stiffener/plate combination

a. Based on yield F_{ty} = 26,000 psi

b. Based on crippling F_{cc} = 19,900 psi

Based on yield F_{ty} = 26,000 psi:

K_4 = 0.816 based on yield

$$C = K_4 \cdot \frac{L}{r} \cdot \left(\frac{F_{ty}}{E}\right)^{\frac{1}{2}} = 0.816 \times \frac{36}{0.892} \cdot \left(\frac{26{,}000}{10.4 \times 10^6}\right)^{\frac{1}{2}} = 1.65$$

for $1.4 < c < 4.8$

$$F_c = (1.235 - 0.168c)\, F_{ty} = \left[1.235 - 0.168(1.65)\right] * 26{,}000$$
$$= 24{,}903 \text{ psi}$$

if pinned $K_4 = 1$ $C = 2.018$ $1.4 < c < 48$

if fixed $K_4 = 0.5$ $C = 1.01$ $C = 1.01 \leq 1.4$

for column allowable

F_c = 24,900 psi (23,298 psi pinned)

$F_c = F_{ty}$ = 26,000 for fully fixed

Based on crippling:

F_{cc} = 19,900 psi - see calculations.

F_{ty} = 26,000 psi cut-off

Stiffener C Mid Span:

$$F_{cw}\Big|_m = .342 \left[(26,000)\ (11.4)\ (10)^6\right]^{\frac{1}{2}} \left(\frac{.2625}{3.01}\right)^{0.75}$$

= 28,540 psi use 26,000 psi

Stiffener @ Support:

$$F_{cw}\Big|_s = .342\ (26,000 \times 10.4 \times 10^6)^{\frac{1}{2}} \left(\frac{.2625}{4.027}\right)^{.75}$$

= 22,942 psi

Plate - Axial:

$$F_{cpa} = 0.366 \left[(26000)(10.4)(10)^6\right]^{\frac{1}{2}} \frac{2x.208}{10}^{.75}$$

t_p = 0.208 b_p = 10 b_p = 8.32

F_{cpa} = 17,531 psi

Plate - Pending:

$$F_{cp} = .366 \left[(26,000)(10.4)(10)^6\right]^{\frac{1}{2}} \left(\frac{2x0.208}{8.32}\right)^{.75}$$

F_{cp} = 20,123 psi

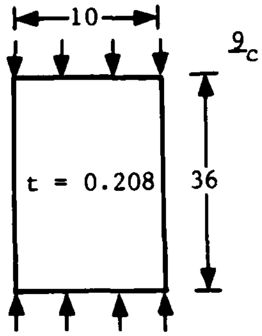


Plate Buckling Stress: σ_{cr}

for $\mu = 0.33 \quad \frac{\pi^2}{12(1-\mu^2)} = 0.923$

FLAT PLATE $\quad \sigma_{cr} = \frac{K_c \, \pi^2 \, M \, E}{12(1-\mu^2)} \left(\frac{t}{b}\right)^2$

where M=1

a. All sides simply supported: $K_c = 4.0$

$\ell = a = 36$
$b = 10$
$a/_b = 3.6$

$$\sigma_{cr} = (4.0)(0.923)(10.4\text{x}10^6)\left(\frac{.208}{10}\right)^2$$

$$\sigma_{cr} = 16{,}612 \text{ psi}$$

b. Loaded edge clamped: $K_c = 4.35$

$$\sigma_{cr} = \left(\frac{4.35}{4.0}\right)(16{,}612) = 18{,}066 \text{ psi}$$

c. One edge free & 3 edges s/s

Ref: Table 6.3 TER037

Flatbar flange: $F_{cr} = .385\ (10.4)(10)^6 \left(\frac{.2625}{3.01}\right)^2$

$= 30{,}452$ psi

d. Ultimate buckling allowable:

$$B = (10/.208) \left(\frac{26{,}000}{10.4\text{x}10^6}\right)^{\frac{1}{2}} = 2.4$$

for B> 1.25 $\quad F_u = 26{,}000 \left(\frac{2.25}{2.4} - \frac{1.25}{2.4^2}\right) = 18{,}712$ psi

Column Buckling Allowable:

Stiffener/plate combination (axial only)

$$F_{ee} = \frac{(26{,}000)\ (3.01)\ (.2625) + (17{,}531)\ (10)\ (.208)}{(3.01)\ (.2625) + (10)\ (.208)} = 19{,}862$$

$$C = (K_4)\left(\frac{L}{\Gamma}\right)\left(\frac{F_{cc}}{E}\right)^{\frac{1}{2}}$$

$K_4 = 0.816 \quad L = 36 \quad \Gamma = 0.892$

$$C = (.816)\left(\frac{36}{.892}\right)\left(\frac{19{,}862}{10.4\text{x}10^6}\right)^{\frac{1}{2}} = 1.44$$

for $1.4 < c < 4.8$ $$F_c' = \left[1.235 - .168\ (1.44)\right] 19{,}862$$

$$F_c' = 19{,}725 \text{ psi}$$

7.8.2.2 Experimental Determination of Buckling of Composite Elements -- The compressive load on the composite panel versus strains at mid span and of end supports are plotted in Figure 7-33 through 7-36 for different test specimens. The panel loaded with only axial load exhibited a "top-of-the-knee" for stiffeners located at midspan as well as at end supports. As can be seen in Figure 7-33 and 7-35 the midspan of panel stiffener is more critical.

The panel loaded axially combined with surface pressure shows a "top-of-the-knee" for the support locations and the mid span being relatively unloaded at the free edge due to pressure effect as indicated in Figures 7-34 and 7-36. These stiffeners were critical at the free edge rather than at the supports.

7.8.3 DISCUSSION OF RESULTS -- All four test panels exhibited considerably higher experimental buckling loads than predicted by analysis with approximately 10% additional past buckling strength before total collapse.

Theoretical versus test values of plate buckling and composite buckling failure for a panel loaded in compression only are illustrated in Figure 7-37. It can be observed that plate buckling values for test and prediction are very close where the actual material modulus values are used in the prediction. Top of the knee values for stiffened panel showever, show about 40% above the predicted values where design yield allowable were used in the analytical equations. On the other hand, when the actual yield values of the panel material are used in the prediction, the results compare with the theoretical analysis. The post buckling strength remains about 10% above the "top-of-the-knee" buckling value. This is considered to be adequate to offset any detriment to strength caused by allowable plate or flat bar warpage or bow.

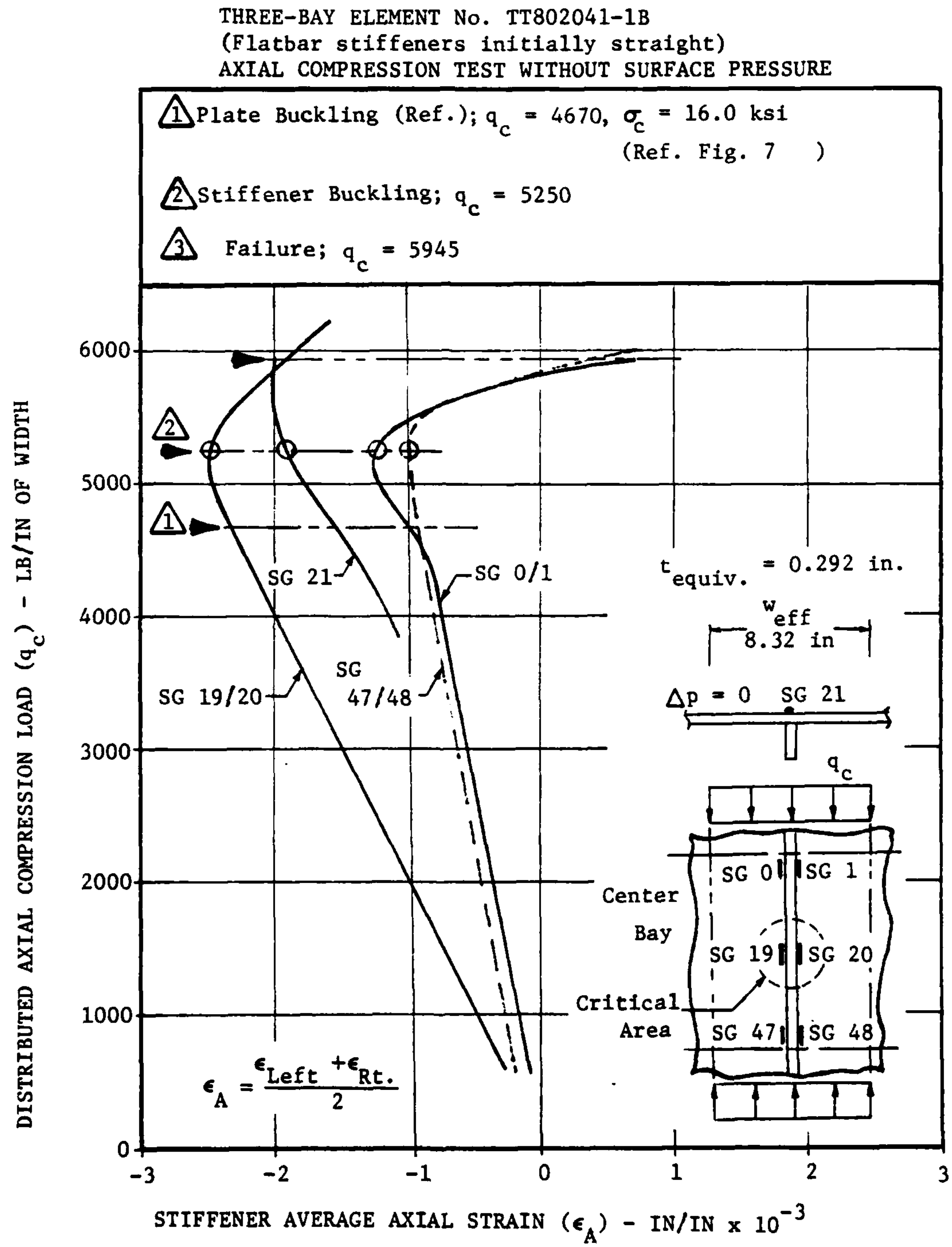


Figure 7-33. Experimental Stiffener Buckling Load - Element No. TT802041-1B, Axial Load Only.

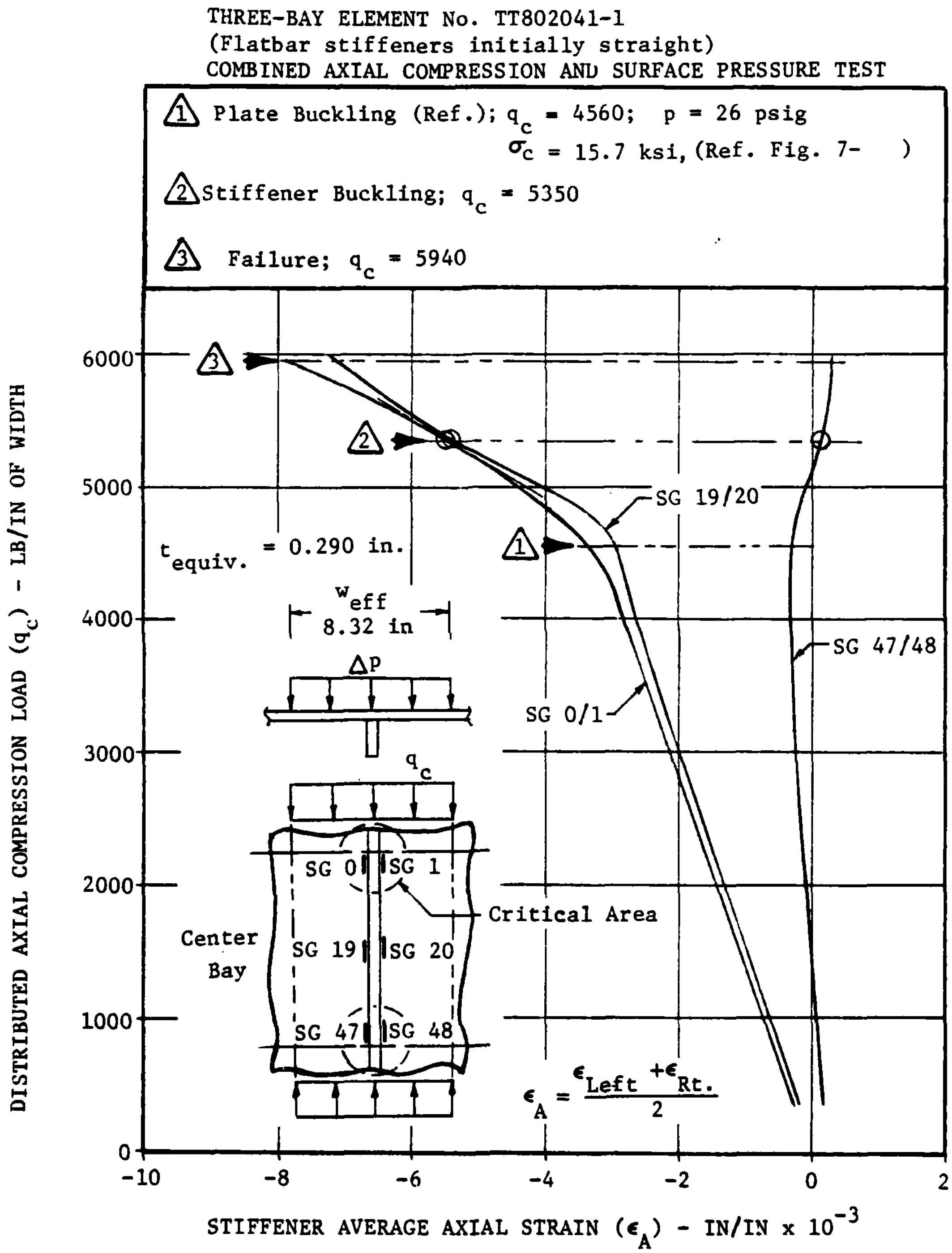


Figure 7-34. Experimental Stiffener Buckling Load - Element No. TT802041-1, Combined Axial Load and Surface Pressure.

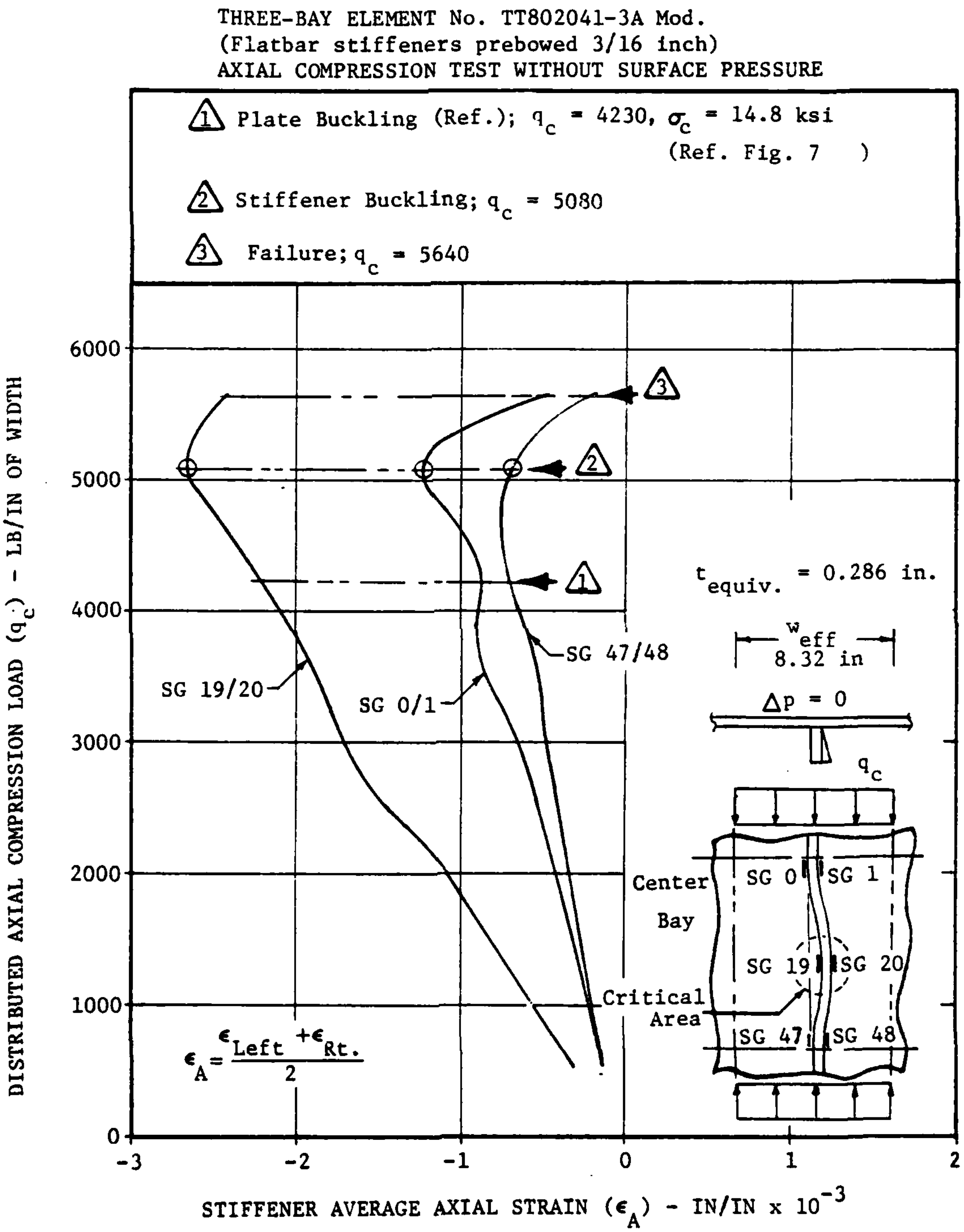


Figure 7-35. Experimental Stiffener Buckling Load - Element No. TT802041-3A Mod., Axial Load Only.

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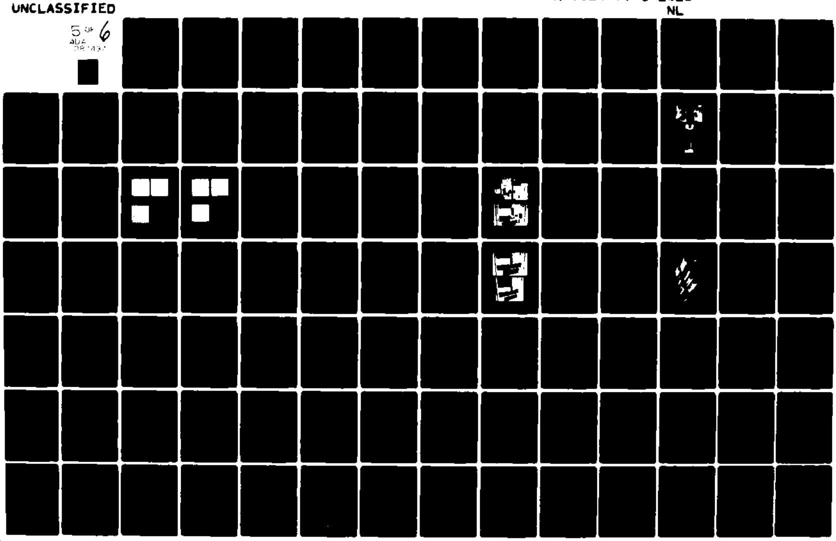

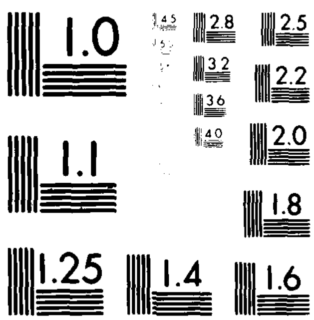

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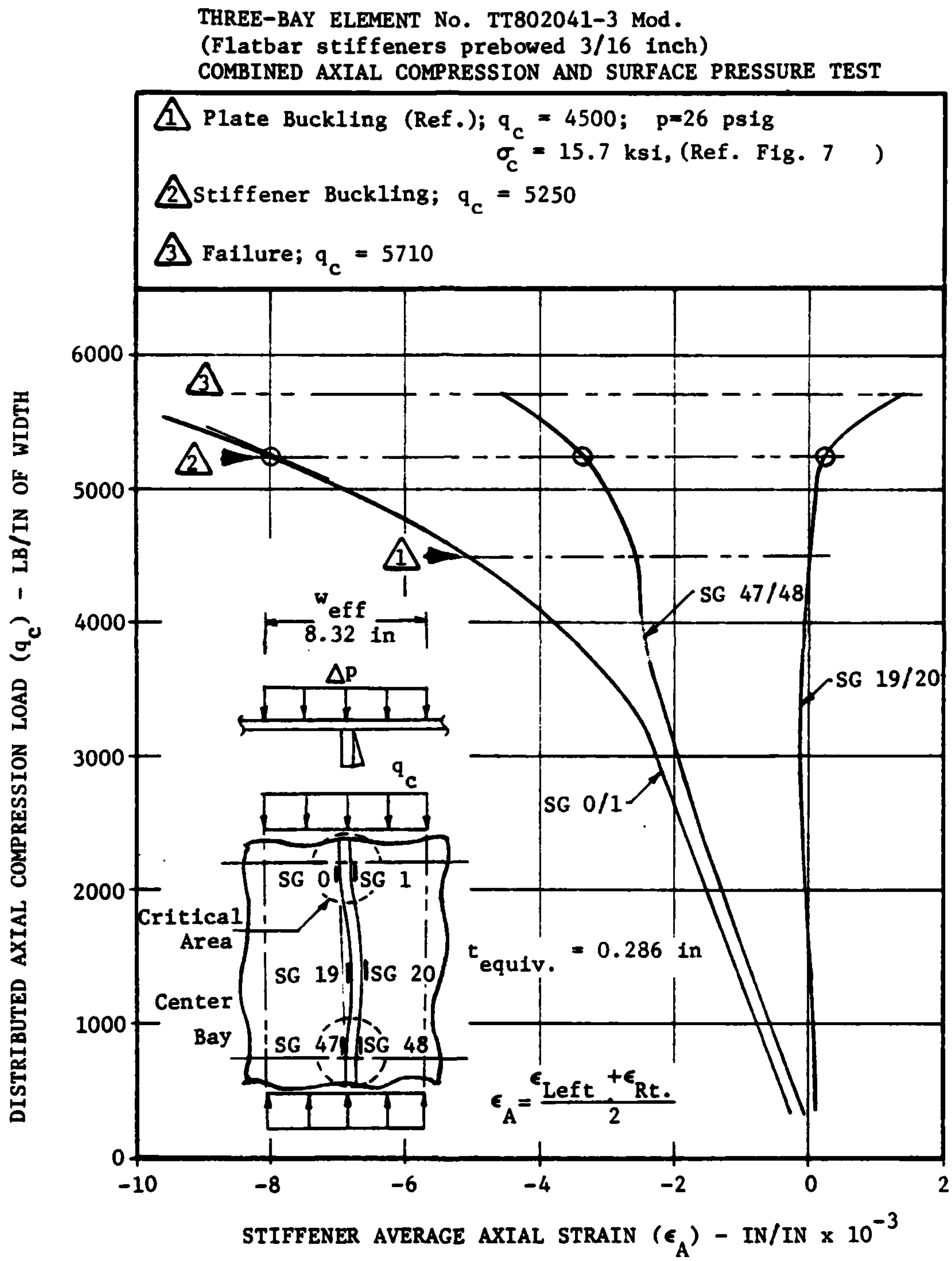


Figure 7-36. Experimental Stiffener Buckling Load - Element No. TT802041-3 Mod., Combined Axial Load and Surface Pressure.

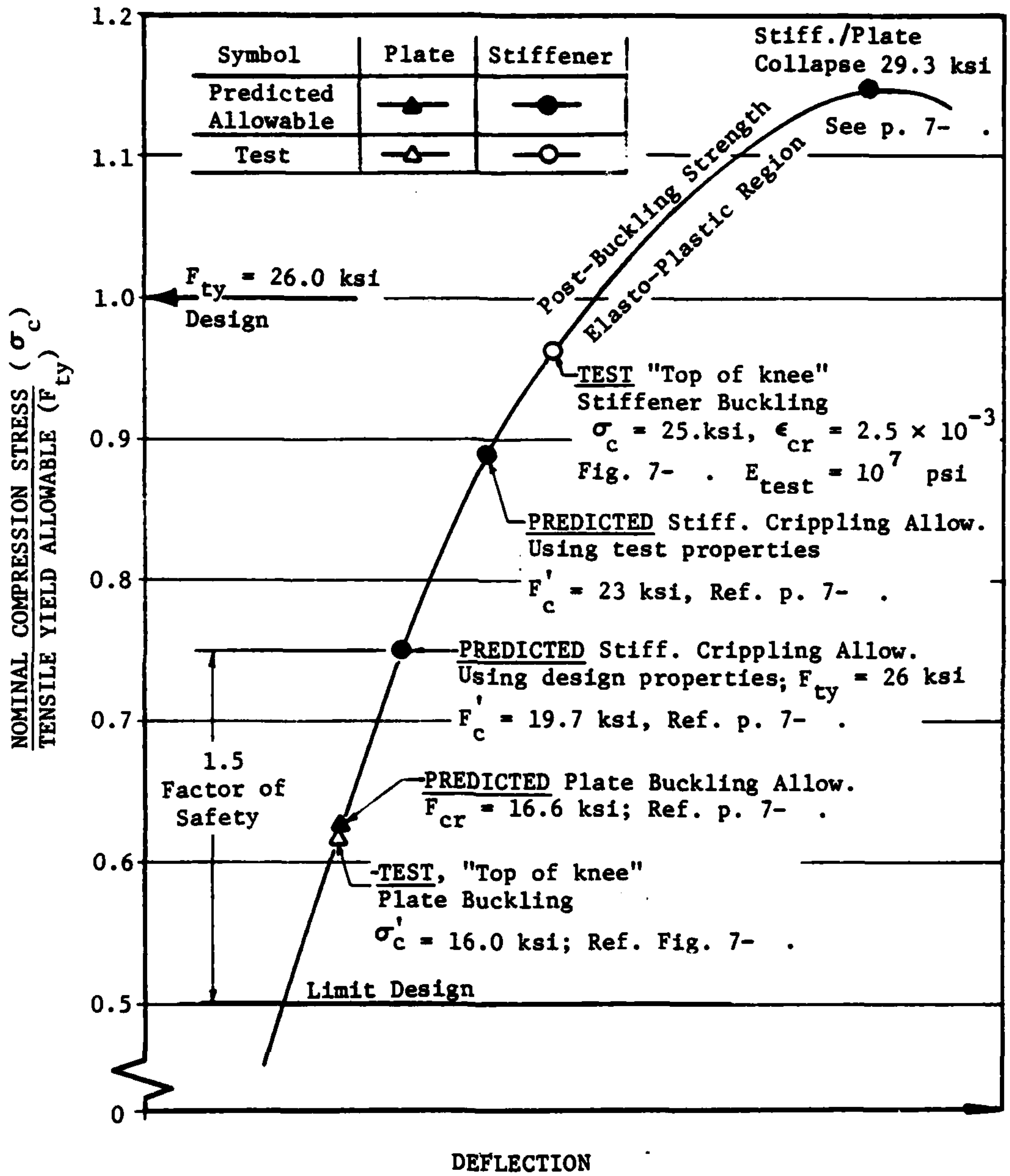


Figure 7-37. Relation of Predicted Allowable vs. Test Results for Three-Bay Element Subject to Axial Compression Load Only.

A comparison between ultimate strengths of bowed and straight flatbar stiffened panels is illustrated in Figure 7-38. Straight flatbar stiffeners show very slight increases in strength than those with 3/16" mid-span bow. This could indicate that the bow had no significant effect on compressive strength of the test panels.

The aspects ratio $^a/b$ - 3.6 of test panels, however, caused plate buckling in 3 half waves in the 36" panel lengths. The design formulas for critical stress values are presented in Reference 18, hence, some of the formulas for predicting buckling limits are given below.

<u>Design Formulas for Critical Buckling Stresses</u>

A. Plate buckling (critical) stress.

$$F_{cr} = F_I^* \; K \frac{E\pi^2}{12\,(1-\mu^2)(K_{19}\,\frac{b_p}{t_p})^2}$$

F_{ty} = Tensile yield stress

F_L = proportional limit stress

$$K \text{ (for very long plates)} = 3.56\,\sqrt{3 + (\frac{fcp}{fs})^2}\left[\sqrt{2.25 + (\frac{fcp}{FS})^2} - \frac{fcp}{fs}\right]$$

For f_s - shear stress - 0 K = 4.0 (see Ref. DDS 1100-3 page 4)

K_{ig} - 1.0 for $b/_a$ - $10/_{36}$ = 0.278

If $F_I^* \leq F_L$ Critical buckling stress F_{cf} - F_I = F_I^*

$$\text{if } F_I^* > F_L \quad F_I = \frac{F_{ty}}{1 + \frac{F_1(F_{ty}-F_1)}{(F_1^*)^2}}$$

B. Stiffener Buckling Stress

Critical buckling stress of flatbar based on plate analysis with one edge free and 3 edges simply supported.

$F_{cr} = 0.383\,(\frac{t_w}{h_m})^2$ t_w = thickness of stiffener

h_m = height of stiffener at mid span

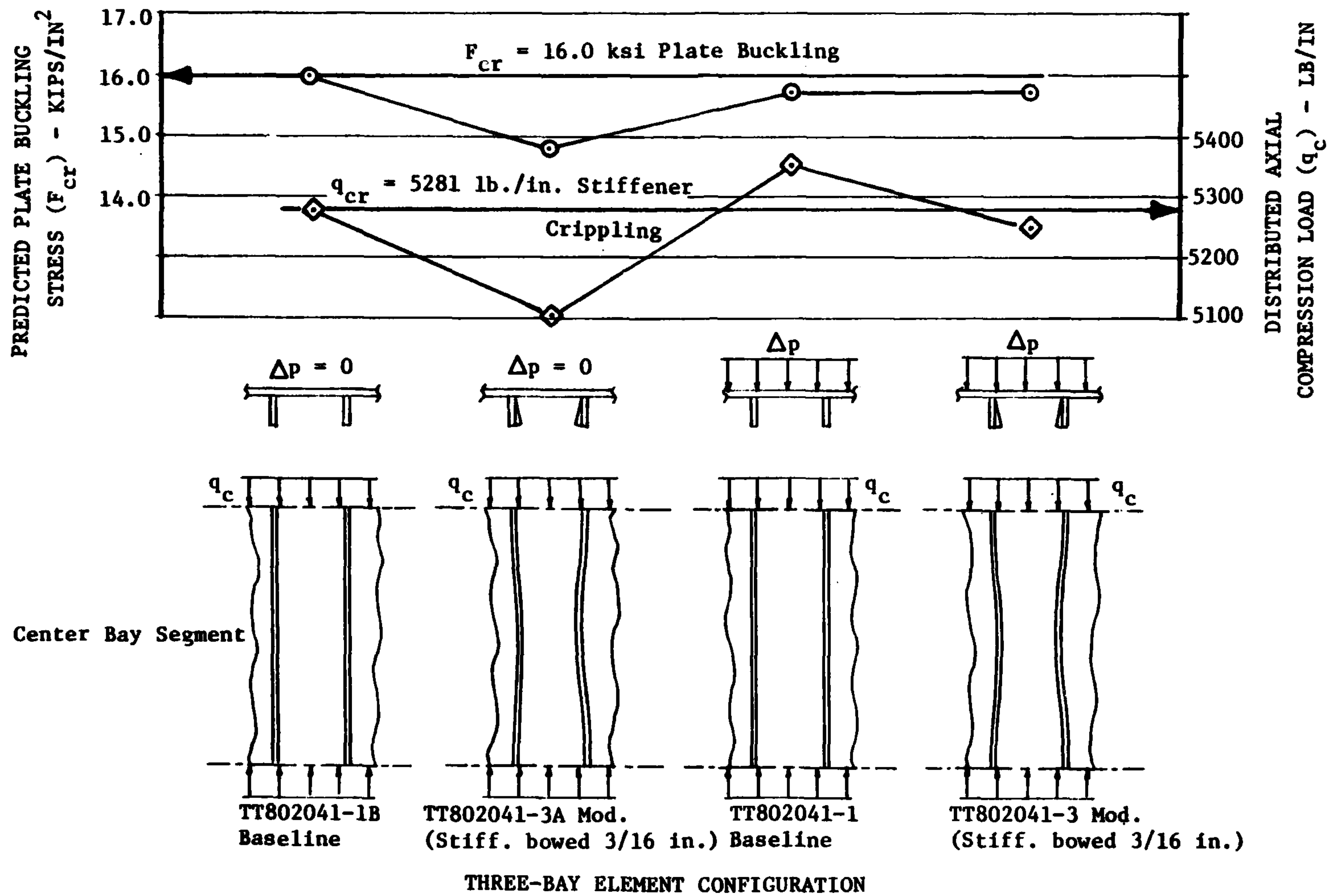


Figure 7-38. Three-Bay Elements Comparative Test Results and Correlation to Theoretical Predictions.

If $F_{cr} > F_L$ $\quad F_I = \dfrac{F_{ty}}{1+\dfrac{(F_{ty}-F_L)\ F_L}{(F_{cr})^2}}$ (See Reference Peery, Aircraft Structures)

C. Ultimate Plate Buckling Stress

$$B = \left(\frac{b_p}{t_p}\right)\sqrt{\frac{F_{ry}}{E}}$$

if B $\leq$ 1.25 $\quad F_u = F_{ty}$

if B $\geq$ 1.25 $\quad F_u = F_{ty}\ (2.26/B - 1.25/B^2)$

D. Column Buckling Allowable

$$C = (K_4 \cdot \frac{L}{r}) \cdot \sqrt{\frac{F_{ry}}{E}} \quad \text{column factor}$$

where K_4 is partial end finity coefficient $K_4 = 0.816$
(Reference DDS-100-4, Strength of structural members)

If C $\leq$ 1.4 (sheet columns) $\quad F_c = F_{ty}$

If 1.4<C <4.3 (medium olumes) $\quad F_c = (1.235 - 0.168C)F_{ty}$

If C>4.8 (long columns) $\quad F_c = (\frac{\pi}{C})^2\ F_{ty}$

E. Column Buckling Allowable Based on Crippling

Bar at support $\quad F_{cws} = 0.342\sqrt{F_{ty} \cdot E}\ (\frac{t_w}{h_s})^{3/4}$

Bar at midspan $\quad F_{cwm} = 0.342\sqrt{F_{ty} \cdot E}\ (\frac{t_w}{h_m})^{3/4}$

Plate (pending) $\quad F_{cp} = 0.366\sqrt{F_{ty} \cdot E}\ (\frac{2tp}{b_p'})^{3/4}$

Plate (axial) $\quad F_{cpa} = 0.366\sqrt{F_{ty} \cdot E}\ (\frac{2tp}{b_p})^{3/4}$

Where b_p' = minimum of $\begin{cases} 2tp\sqrt{\frac{E}{f_{ty}}} \\ \text{or} \\ b_p \end{cases}$

If stiffened plate combination is used

$$C = K_4 \frac{L}{r} \frac{F_{cc}}{E}$$

$$F_{cc} = \frac{F_{cwm} h_m t_w + F_{cpa} b_p t_p}{h_m t_w + b_p t_p}$$

$K_4 = 0.816$ (partial fixity)

if $C \leq 1.4$ $\qquad F_c' = F_{cc}$

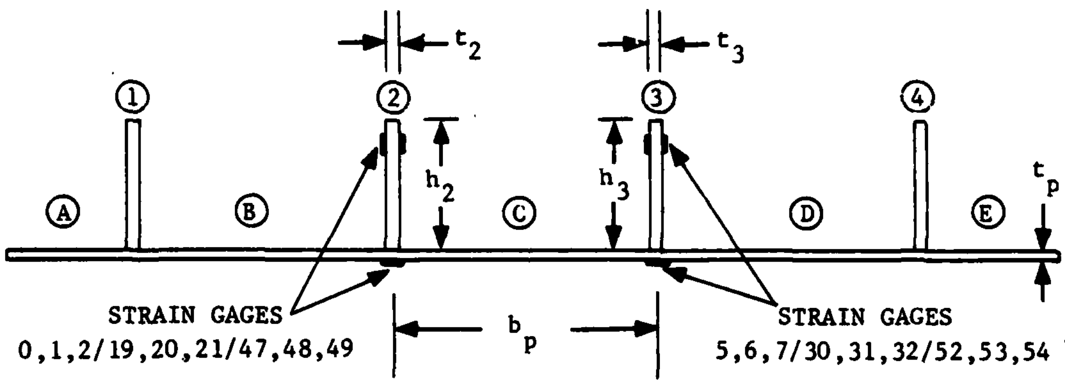
if $1.4 < C < 4.8$ $\qquad F_c' = (1.235 - 0.168C)\, F_{cc}$

if $C \geq 4.8$ $\qquad F_c' = (\pi/C)^2 \quad F_{cc}$

The panel dimensions used in predicting theoretical stress values are illustrated in Table 7-4 and Table 7-5. The material properties of each test specimen are given in Table 7-6. Using the actual panel dimensions and material properties given in Tables 7-4 through 7-6. The predicted design values for plate buckling, column buckling, crippling and stiffener buckling are obtained and shown in Table 7-7.

Table 7-4. Panel Dimensions used in Theoretical Correlation Analysis

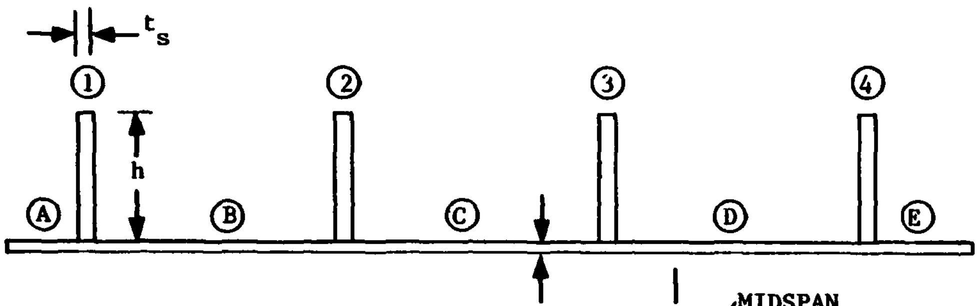
SPECIMEN IDENTIFICATION	b_p (in)	t_p (in)	h_2 (in)	t_2 (in)	h_3 (in)	t_3 (in)	Γ
041-1	10.0	.208	3.047/4.030	.263	3.000/4.101	.256	.906/.884
041-B	10.0	.208	3.987/4.019	.261	3.032/4.047	.264	-8°3/.901
041-3A Mod	10.0	.203	2.956/4.000	.252	2.930/3.967	.256	-874/.868
041-3	10.0	.210	3.028/3.981	.257	2.998/3.967	.255	-891/.878



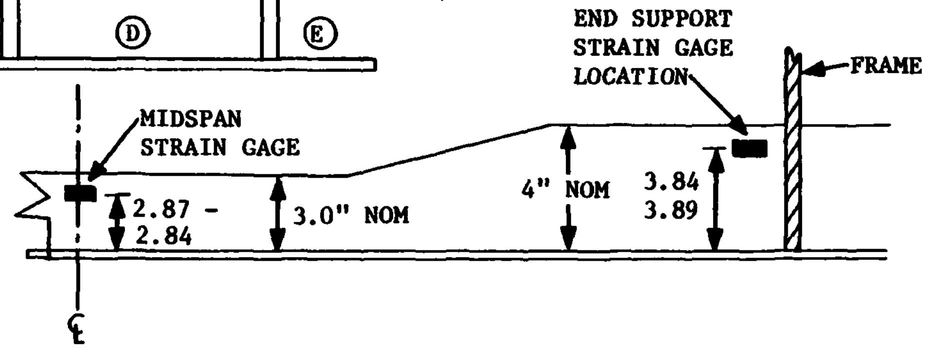
t_p = plating thickness

h = stiffener height (midspan height/end support height)

r = radius of gyration = $(^I/A)^{1/2}$ = midspan/end support



h = stiffener height
t_s = stiffener thickness
t_p = plating thickness



SPECIMEN IDENTIFICATION	t_a	t_b	t_c	t_d	t_e	PLATING THICKNESS AVERAGE t_p	t_1	t_2	t_3	t_4	STIFFENER THICKNESS AVERAGE t_p	h_1 Mid/End	h_2 Mid/End	h_3 Mid/End	h_4 Mid/End	STIFFENER HEIGHT AVERAGE Mid/End
041-1 Straight Stiffeners	.025	.206	.208	.208	.209	.2072	.255	.263	.256	.258	.2580	2.988 4.000	3.047 4.030	3.006 4.010	3.034 4.000	3.0138 4.010
041-B Straight Stiffeners	.211	.210	.208	.206	.205	.2080	.261	.261	.264	.260	.2615	3.009 4.000	2.987 4.019	3.032 4.047	3.012 4.000	3.0100 4.0165
041-3A Mod 3/16"Bowed Stiffners	.204	.204	.203	.200	.199	.2020	.254	.252	.296	.250	.2530	3.008 4.000	2.956 4.000	2.930 3.967	2.995 4.000	2.9723 3.9918
041-3/041-3 Mod 3/8" Bow/3/16" Bow	.201	.201	.210	.209	.204	.2050	.252	.257	.255	.258	.2555	2.970 4.000	3.028 3.981	2.955 3.967	2.970 4.000	2.9908 3.9870

Table 7-5. 3-Bay Panel Dimensions for Section Properties Calculations

Table 7-6. Three-Bay Test Panel Material Mechanical Properties

PANEL IDENTIFICATION		TENSILE PROPORTIONAL LIMIT (KSI)	TENSILE YIELD (KSI)	TENSILE ULTIMATE (KSI)	ELONGATION %	TENSILE MODULUS (PSI)x10^6
041-1	Plate	29.7	36.6	52.6	13.9	10.22
	Stiffner	35.0	40.9	53.2	12.8	10.28
041-1B	Plate	31.2	36.6	52.9	13.2	9.89
	Stiffner	30.2	40.4	53.7	13.2	9.51
041-3	Plate	22.1	32.2	50.3	15.5	9.90
	Stiffner	32.9	40.0	53.3	14.8	9.99
041-3A MOD	Plate	30.5	34.6	52.1	14.0	10.34
	Stiffner	32.5	39.7	52.4	16.1	9.51
Design Values Used		20.0	26.0	40.0	12.0	10.4

Table 7-7. Critical Buckling Stresses Using Design Formulas with Three-Bay Test Panel Material Properties

SPECIMEN IDENTIFICATION	PLATE BUCKLING STRESS ALL EDGES SIMPLY SUPPORTED	STIFFENER BUCKLING STRESS ONE EDGE FREE, THREE EDGES SIMPLY SUPPORTED		• ULTIMATE PLATE BUCKLING ALLOWABLE	COLUMN BUCKLING ALLOWABLE	CRIPPLING COLUMN BUCKLING ALLOWABLE	CRIPPLING							
							STIFFENER AT MID SPAN		STIFFENER AT END SUPPORT		PLATE			
		MID SPAN	END SUPPORT				2	3	2	3	AXIAL	BENDING		
041-1	16,612	[2]29,831 [3]29,156	17,053 16,319	23,096	[2]33,270 [3]32,973	[2]23,895 [3]23,561	35,314	35,313	28,633	28.165	20,619	23,669	24,706	24,500
041-B	16,612	[2]30,571 [3]30,356	16,886 17,039	22,808	[2]32,311 [3]32,764	[2]22,936 [3]23,109	34,069	33.979	27,271	27,363	20,283	23,283	24,042	24,089
041-3A Mod	15,823	[2]29,100 [3]30,566	15,892 16,674	21,992	[2]30,946 [3]30,865	[2]22,333 [3]22,437	33,154	33,771	26,425	26,906	19,800	23,148	23,385	23,570
041-3	16,933	[2]28,864 [3]28,968	16,687 16,540	21,220	[2]29,595 [3]29,445	[2]22,415 [3]22,291	33,996	34,050	27,688	27,599	19,172	21,850	23,189	23,143

7.9 CONCLUSIONS

The following conclusions are based on the results of the three-bay panel element static tests described in previous sections and are applicable to these specific specimen configurations and tests.

1. All test specimens continued accepting load well into the elasto-plastic region which is not taken into consideration by the 3KSES analytical approach.
2. The presence of lateral prebowing (up to 3/16") in the flatbar stiffeners has little, if any, effect on the load-carrying capability of the structure either at the elastic limit or at failure.
3. Flatbar stiffeners with 3/8 inch lateral prebow considerably degrade the load-carrying capacity of the structure within the proportional limit.
4. Within the tested range of combined loads, the proportional application of normal pressure to the plate side of the test specimens with simultaneous axial compression load had little effect on the nominal axial compression failure stress.

8 / SUPPLEMENTAL TESTS

8.1 GENERAL

During the course of the panel and element structural test program, additional requirements for engineering data were identified in three separate areas beyond the scope of the Reference 1 and 2 test plans. This data was needed to substantiate design concepts and to evaluate a potential approach for structural weight reduction. The three areas of data needed included transverse direction mechanical properties for 5456-H111 aluminum extrusions, the effects of high strain rates on 5456-H117 aluminum mechanical properties, and allowable limits for sidehull fence bearing on drydock cap blocking. After literature searches proved unsuccessful, a brief test program was conducted for each of the three areas of need.

Complete descriptions of these supplemental tests including rationale, objectives, results and conclusions are presented below. The extrusion directional property tests are presented in Section 8.2; the high strain rate tests, in Section 8.3; and the cap block bearing tests, in Section 8.4.

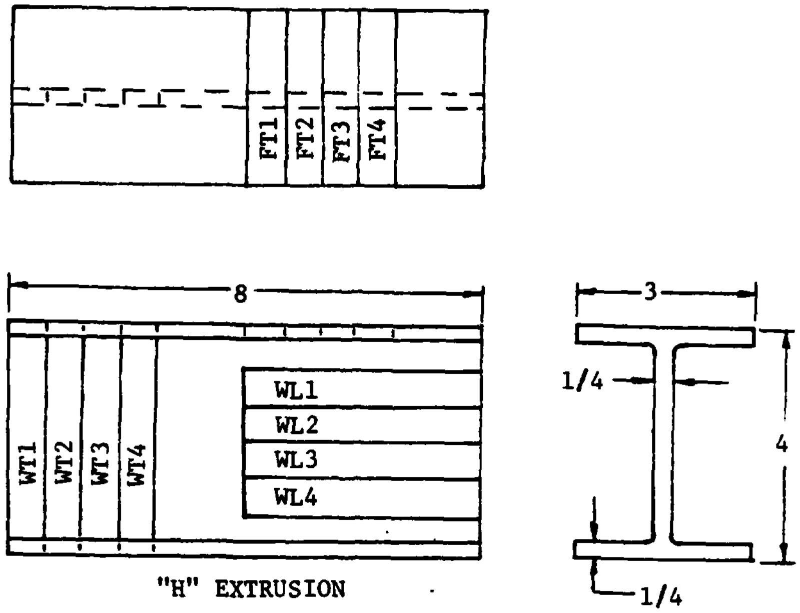
8.2 EXTRUSION DIRECTIONAL PROPERTIES

8.2.1 OBJECTIVE AND SCOPE -- Extruded shapes used in the design of the 3KSES hull structure can be subject to significant stresses

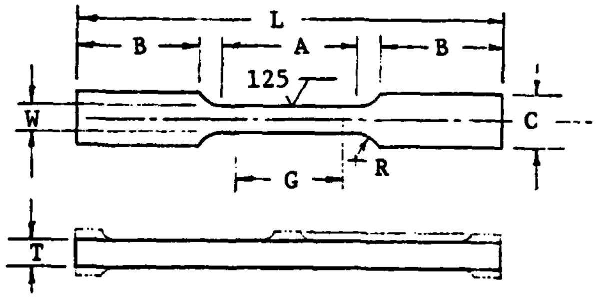
acting in directions perpendicular to the extrusion longitudinal axis. Therefore, the need was established for information concerning the strength of 5456 aluminum alloy extrusions in the transverse directions. A brief survey of available mechanical property data was conducted, but no data was located for either the transverse properties or the expected variation in the directional properties of these extrusions. A minimal test program, as described below, was then implemented to acquire exploratory information.

The primary objective of this investigation was to determine, from one representative extruded shape of 5456-H111 aluminum alloy, the variation in mechanical properties for three mutually perpendicular directions. Specific data to be acquired included tensile yield strength, tensile ultimate strength and elongation. Data was to be obtained from an "H"-section extrusion in the web longitudinal, web transverse, and flange transverse directions. Four test samples in each direction were planned.

8.2.2 SPECIMEN DESCRIPTION -- All of the test specimens were obtained from a length of 5456-H111 aluminum alloy "H"-section extrusion per Federal Specification QQ-A-200/7. Dimensions of the extrusion and the locations and orientations of the individual test specimen blanks are depicted in Figure 8-1(a). The test specimens were machined from these blanks to the configurations shown in Figure 8-1(b). Dimensions of the test specimen reduced sections were in conformance with the requirements for the Subsize Rectangular Tension Test Specimen per ASTM-E8-78 Reference 19. Dimensions of the specimen end grip areas were modified from those shown in the ASTM standard. Actual cross-section dimensions for each specimen tested are tabulated with the test results in Section 8.2.5.



a) Specimen Locations and Orientations



DIMENSIONS - INCH		
	SPECIMEN TYPE	
SYMBOL	WL & WT	FT
A	1 1/4	1 1/4
B	1 1/8	5/8
C	1/2	1/2
G	1.000 ± .003	1.000 ± .003
L	4	3
R	1/4	1/4
T	1/4	1/4
W	.250 ± .002	.250 ± .002

b) Test Specimen Dimensions

Figure 8-1. Extrusion Properties Test Specimen Locations and Dimensions.

8.2.3 TEST SETUP -- All tests were conducted at the Rohr Industries Mechanical Test Laboratory using the 50,000 pound capacity Instron Model TTK-50 Universal Testing Machine previously described in Section 4.4.1. Wedge type grips were used to connect to the specimen ends. A standard class B-1 extensometer with a one-inch gage length was aligned and attached to gage marks scribed on the reduced section of each specimen. This extensometer was wired to the Instron test machine servo recorder to provide a load versus strain curve.

8.2.4 TEST PROCEDURES -- Prior to test, the actual width and thickness at the rediced section of each specimen was accurately measured and recorded. Each specimen was then mounted in the test machine grips and the extensometer was attached. When preparations were complete, loading was applied. The rate of loading was controlled to produce 50 ski (reduced area stress) per minute. This rate was maintained through the specimen yield as indicated on the recorded chart. The extensometer was then removed and the rate of loading was increased by switching to a preset head travel rate of 0.2 inch per minute. This rate was maintained until specimen fracture. Measurements of the total elongation at fracture were obtained for each specimen after test.

8.2.5 TEST RESULTS -- Data obtained from the extrusion directional properties tests are presented in Table 8-1 and plotted in Figure 8-2. The average values for each group of data are also shown in Figure 8-2. The highest values of ultimate strength and ductibility were measured for the web transverse direction; lowest values for these parameters were measured in the web longitudinal direction. However, yield strength was highest in the web longitudinal direction and lowest in the flange transverse direction. The maximum spreads in the individual test data points for ultimate strength, yield strength and elongation were 6.3., 20.6 and 16.7 percent respectively. For the test data group averages, the corresponding spreads were 3.2, 14.5 and 13.1 percent.

Table 8-1. Extrusion Directional Property Test Data

Specimen Ident.	Specimen Test Section Dimen. Width (in)	Thickness (in)	Area (in^2)	Tensile Yield Stress (ksi)	Tensile Ultimate Stress (ksi)	Elongation [1] (percent)
WL-1	.2460	.2530	.0622	30.5	47.0	22.7
WL-2	.2455	.2528	.0604	31.5	48.4	21.7
WL-3	.2437	.2535	.0618	29.9	46.1	22.1
WL-4	.2408	.2530	.0609	30.8	47.6	21.8
WT-1	.2441	.2520	.0615	27.8	48.8	25.0
WT-2	.2443	.2530	.0618	27.0	48.5	24.8
WT-3	.2450	.2517	.0617	28.2	49.0	24.5
WT-4	.2466	.2518	.0621	27.9	48.7	25.8
FT-1	.2470	.2456	.0607	26.9	47.8	22.8
FT-2	.2470	.2438	.0602	26.9	48.2	24.6
FT-3	.2468	.2445	.0603	27.2	48.1	24.0
FT-4	.2435	.2455	.0598	26.1	48.5	24.2

[1] Measured in 1.0 inch gage length

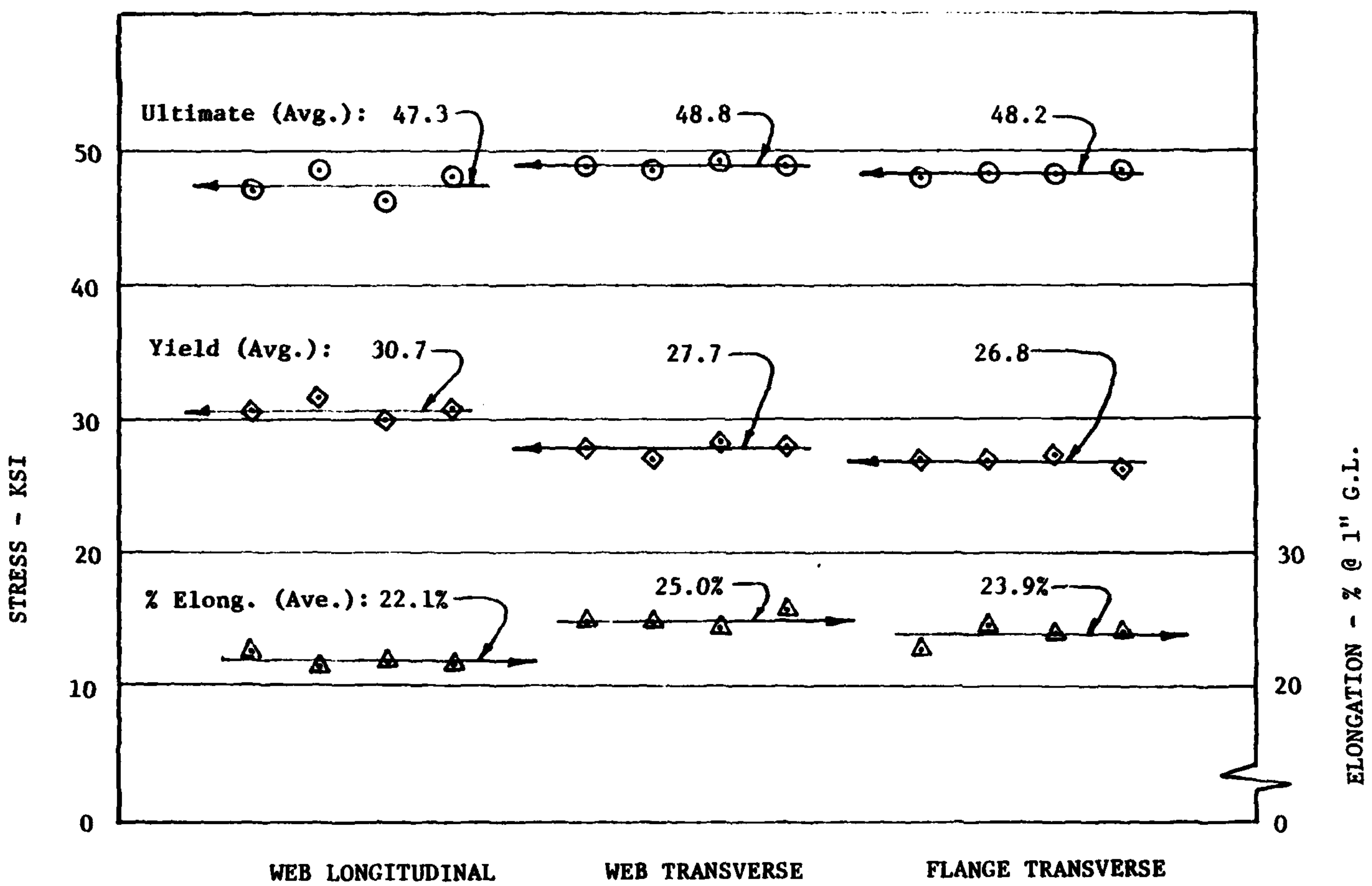


Figure 8-2. Extrusion Directional Properties Test Results.

8.2.6 CONCLUSIONS -- Based on the results of the tests described above, the 5456-H111 aluminum alloy H-section extrusion exhibited the highest ultimate strength in the web transverse direction and the lowest in the web longitudinal direction. However, yield strengths of this extrusion were highest in the web longitudinal direction and lowest in the flange transverse direction. Therefore, the use of published longitudinal direction ultimate strength data for 5456-H111 extrusions may tend to be conservative for loadings applied in the transverse directions. By contrast, the use of published longitudinal direction yield strength date may tend to be unconservative by as much as 13 percent when applied to loadings in the transverse directions.

8.3 HIGH STRAIN RATE TESTS

8.3.1 OBJECTIVE AND SCOPE -- It is well known that the strength, elongation, and other mechanical properties of metals are more or less dependent on the strain rate employed during the tests conducted to measure these properties. This strain rate sensitivity varies with different metals and alloys among other factors, but in general, most metals tend to exhibit higher strength with increasing strain rate.

Among the highest structural design loads for the 3KSES are those of an impulsive nature, e.g., bow slamming. In certain critical design cases, the rate of 3KSES structural loading (strain) is more than two orders of magnitude greater than the strain rates employed during standard coupon tests to determine mechanical properties. A potential for 3KSES structural weight reduction would therefore exist if an increase in the structural material allowables could be established for the impulsive loading strain rates. A survey of available data revealed a limited amount of information on the strain rate sensitivity of several aluminum alloys, but no data was located for type 5456-H116 plate or welded joints. A test program, as described below, was therefore implemented to acquire data for design guidance.

The primary objective of this experimental investigation was to determine the room temperature strain rate sensitivity of butt welded 0.250 inch thick 5456-H116 aluminum alloy plate over a range of strain rates extending from 0.05 per minute to 1.0 per second. Specific data to be acquired at each strain rate included tensile yield strength, tensile ultimate strength, percent elongation and actual recorded load versus elongation curves. Yield strength and total elongation data for both 2 inch and 10 inch gage lengths were required.

The lower boundary of the planned range of test strain rates, 0.05 per minute, was selected to match the standard rate employed by Rohr Industries for coupon mechanical property tensile tests. The planned upper boundary test strain rate was selected, as described below, to exceed the loading strain rate predicted for the 3KSES structure. The predicted time history for a 3KSES bow slam impulse loading condition is shown in Figure 8-3. The two load rate lines superimposed on this figure depict both the maximum instantaneous and the average loading rates. Rate magnitudes were based on the premise that the structure reaches material yield strength at the peak imposed load. Using 0.005 as the approximate total strain at material yeild, the maximum instantaneous loading rate shown in Figure 8-3 equated to a strain rate of 0.25 per second. For conservatism a planned boundary test strain rate of 1.0 per second was established.

A complete matrix of the planned tests is presented in Table 8-2.

8.3.2 SPECIMEN DESCRIPTION -- All of the specimens for this investigation were obtained from four essentially identical transverse welded flat plat assemblies fabricated per RMI Drawing No. TK801021 (Reference Appendix A). The plate material was 0.25 inch thick 5456-H116 aluminum alloy per Federal Specification QQ-A-250/20. These plates were square groove butt welded single pass from one side using type 5556 filler wire and grooved, anodized aluminum backup bars. The gas-metal-arc welding process was employed. Both the face and root weld

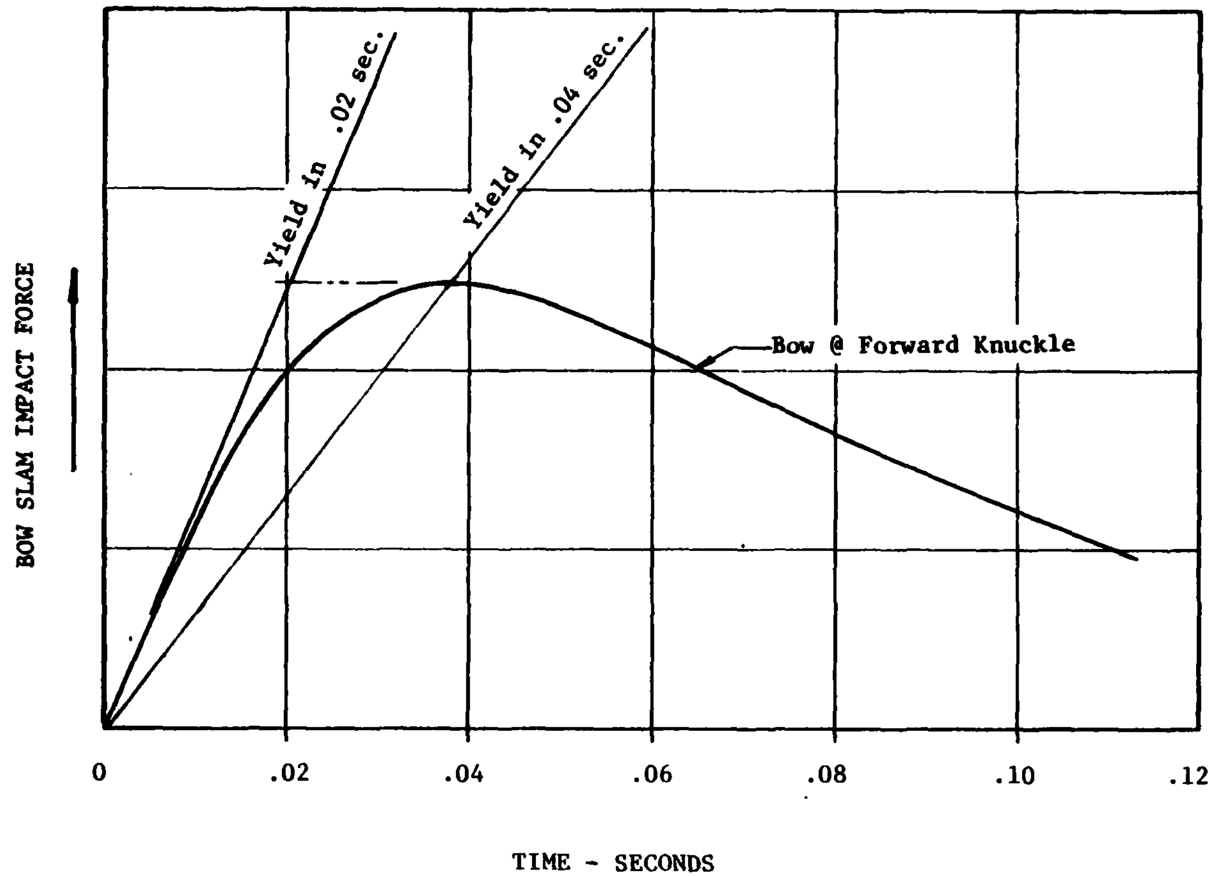
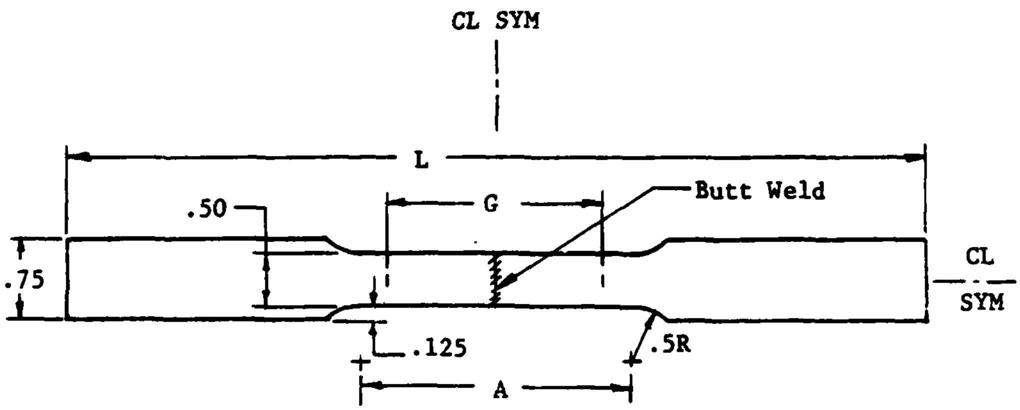


Figure 8-3. Representative 3KSES Impulse Loading Time History.

Table 8-2. Planned High Strain Rate Test Matrix.

Gage Length (in)		Strain Rate (in/in/sec)				Specimen Quantity
2	10	.000833	.04	.2	1.0	
X		X				2
X			X			3
X				X		3
X					X	4
	X	X				4
	X		X			4
	X			X		4
					Total	24



DIMENSIONS - INCH		
SYMBOL	SPECIMEN GAGE LENGTH	
	2	10
G	2.00	10.00
A	2.25	11.00
L	8.0	17.0

Figure 8-4. Specimen Configurations for High Strain Rate Tests.

bead reinforcements were subsequently removed flush to the base metal surface. All welds were 100 percent radiographically examined, and all met Class 1 acceptance standards per NAVSEA 0900-LP-003-9000, Reference 20. Each welded plate assembly, with a finished size of 17 by 24 inches, was identified A, B, C, or D.

A total of 48 individual test specimens were machineed from the plate assemblies per RMI Drawing No. TK801021. One group of 24 specimens was machined in accordance with the requirements of ASTM E8-78 (Reference 19), Figure 6, Standard Specimen, Sheet Type to provide 2-inch gage lengths. The second group of 24 specimens was machined to the same standard except that the gage lengths were increased to 10 inches. The configurations and dimensions of these specimens are illustrated in Figure 8-4. Twelve specimens of each gage length, randomly selected from the four welded plate assemblies, were retained for testing by Rohr Marine. An equivalent group of 24 machined specimens was supplied to the Naval Ship Research and Development Center.

8.3.3 SPECIMEN PREPARATION -- Prior to test all surfaces of each machined specimen were hand worked with emory cloth to a surface finish of approximately 16 micro-inches. Appropriate gage length marks were then added to each specimen by scribing or center punching.

8.3.4 TEST SETUPS -- Four of the 24 specimen tests were conducted at the Rohr Industries Mechanical Test Laboratory. These tests, requiring the lowest strain rates, were conducted in the 50,000 pound capacity Instron Model TTK-50 Universal Testing Machine previously described in Section 4.4.1. Wedge type grips were used to connect to the specimen ends. A standard Class B-1 extensometer of the appropriate gage length was attached to the reduced section of each specimen and wired to the Instron servo recorder to provide a load-strain curve.

The remaining 20 specimen tests, including all of those requiring accelerated strain rates, were conducted at the General Dynamics Convair Division Mechanical Test Laboratory located in San Diego. These tests were conducted in an MTS 909.95 closed loop test system setup as shown in Figure 8-5 using wedge grips for connecting to the specimen. A calibrated, strain gaged, slip type extensometer of appropriate gage length was attached to the specimen as shown in Figure 8-6. The extensometer strain gage was wired to the MTS system X-Y recorder to provide load-deformation curves for tests conducted at the lower strain rates. When testing at the higher strain rates, it was necessary to connect the extensometer and the test machine load cell to an oscilloscope. A Polaroid camera attachment was used to record the displayed load versus elongation traces.

8.3.5 TEST PROCEDURES -- Prior to test, the actual width and thickness at the rediced section of each specimen was accurately measured and recorded. Each specimen was then mounted in the test machine grips and the proper length extensometer was attached. The test machine loading head travel rate was preset based on the specified strain rate and the specimen gage length. When all preparations were complete, the test machine was started and loading was continued uninterrupted until specimen fracture. All but three of the specimens were tested at the planned strain rate; tests on these three were performed at one-half the planned strain rate.

For the tests conducted at Rohr, the extensometer was removed from the specimen after the chart recorder indicated that the yield point had been attained. At Convair, the extensometer normally remained in place. When the oscilloscope was utilized, the Polaroid camera attachment was triggered manually.

Recorded data for each test included the load-strain charts and/or Polaroid prints and the loads at failure. Measurement of the total elongation at fracture was also recorded for each specimen after test.

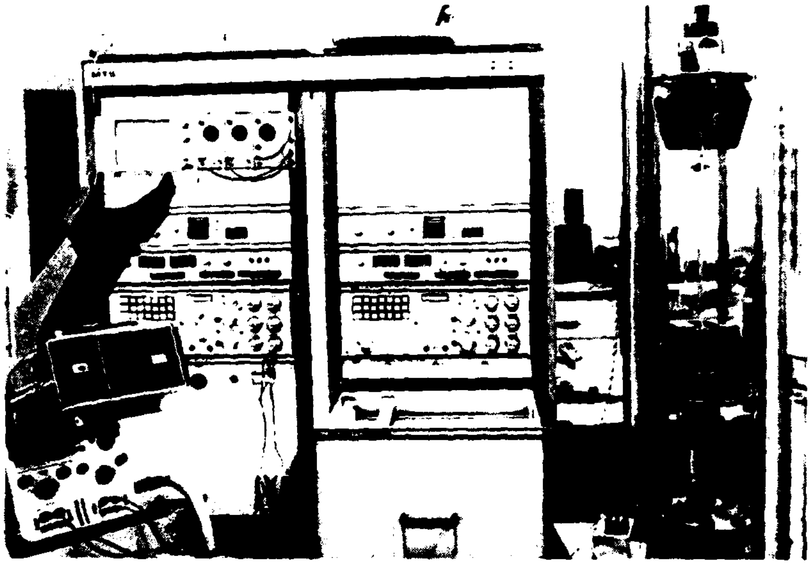


Figure 8-5. (790800-1) General Dynamics High Strain Rate Test System Setup

Figure 8-6. (790800-2) Detail of Specimen Installation and Chip Type Extensometer.

8.3.6 TEST RESULTS -- Data obtained from the high strain rate tests conducted under the direction of Rohr Marine are presented in Table 8-3 and graphically displayed in Figure 8-7. As shown in Figure 8-7 the test results show slight decreases in the ultimate strength and the yield strength for a 2-inch gage length between the standard static test strain rate and the lowest of the accelerated strain rates. These parameters remained essentially unaffected as the strain rates were increased up to the maximum values tested. For yield strength in a 10-inch gage length, the upper boundary of test values decreased with increasing strain rate, but the lower boundary remained flat over the full range of strain rates tested.

Representative load versus strain curves recorded during testing are presented in Figures 8-8, 8-9 and 8-10 for selected specimens. Figure 8-8 compares the load-strain chart records for typical 2-inch and 10-inch gage length specimens tested at the standard strain rate used for coupon static tests. A stress instability observed for certain aluminum alloys tested at low strain rates, the Portevin-Le Chatelier effect, is readily apparent as serrations in the load-strain curve for Specimen D-18. Although not recorded, this effect was also observed for Specimen A-17 at higher strain levels. In fact, this instability was apparent in all specimens tested at the lower strain rates.

The load-strain oscilloscope traces shown in Figure 8-9 for 2-inch gage length specimens show little or not variation over the range of accelerated strain rates. Similar traces presented in Figure 8-10 for 10-inch gage length specimens reflect essentially the same lack of variation. In both of these figures, the oscillations visible in the linear portions of the load-strain curves were attributed to "ringing" of the slip extensometer caused by the sudden onset of loading at the high strain rates.

Table 8-3. High Strain Rate Test Results
(All specimens transverse butt welded)

Gauge Length (in)	Test Strain Rate (in/in/Sec)	Specimen Ident.	Specimen Test Sect. Dimen. Width (in)	Thickness (in)	Area (in^2)	Yield Stress[1] (ksi)	Ultimate Stress (ksi)	Elong. (%)	Load-Strain Curve Fig. No.
2	1.0	A-19	.4995	.2465	.1231	20.6	41.4	11.0	----
	1.0	A-20	.5005	.2505	.1254	20.9	40.7	11.5	8-9(a)
	1.0	B-6	.5135	.2525	.1297	20.2	40.1	12.5	----
	.5[2]	A-18	.4890	.2495	.1220	19.7	41.0	----	----
	.2	A-21	.5010	.2495	.1250	21.0	40.6	11.5	8-9(b)
	.1[2]	A-22	.4990	.2510	.1252	21.0	41.5	12.0	8-9(c)
	.1[2]	B-7	.5140	.2525	.1298	20.4	40.5	12.5	----
	.04	A-23	.5050	.2540	.1283	18.7	39.8	11.0	----
	.04	A-24	.5090	.2520	.1283	20.6	40.1	10.5	----
	.04	B-8	.5055	.2525	.1276	20.1	40.3	11.5	8-9(d)
	.000833	A-17[3]	.4930	.2545	.1255	21.5	43.4	11.2	8-8
2	.000833	B-5[3]	.5110	.2552	.1304	21.1	42.6	10.9	----
10	.2	C-19	.4970	.2535	.1260	27.0	40.1	2.2	----
	.2	C-20	.4945	.2520	.1246	26.6	39.6	2.4	----
	.2	D-19	.5180	.2505	.1298	26.8	40.0	2.9	8-10(a)
	.2	D-20	.5210	.2505	.1305	26.4	40.2	3.0	----
	.04	C-21	.4925	.2550	.1256	26.7	39.8	2.5	----
	.04	C-22	.4900	.2530	.1240	26.5	39.5	2.4	----
	.04	D-21	.5210	.2470	.1287	26.4/ 28.0[4]	40.4	2.6	8-10(b)
	.04	D-22	.5095	.2535	.1292	25.7/ 26.5[4]	39.4	2.1	----
	.000833	C-17[3]	.4992	.2560	.1278	26.4	41.9	2.7	----
	.000833	C-18[3]	.4995	.2560	.1279	26.0	41.8	2.7	----
	.000833	D-17	.5245	.2530	.1327	27.9/ 28.6[4]	43.0	3.2	8-10(c)
10	.000833	D-18	.5185	.2565	.1330	27.4/ 28.0[4]	42.7	3.4	8-8

[1] .2% offset based on specified gage length.

[2] Tested at one-half planned strain rate.

[3] Tests conducted by Rohr Industries.

[4] First value from oscilloscope trace/second from chart recorder.

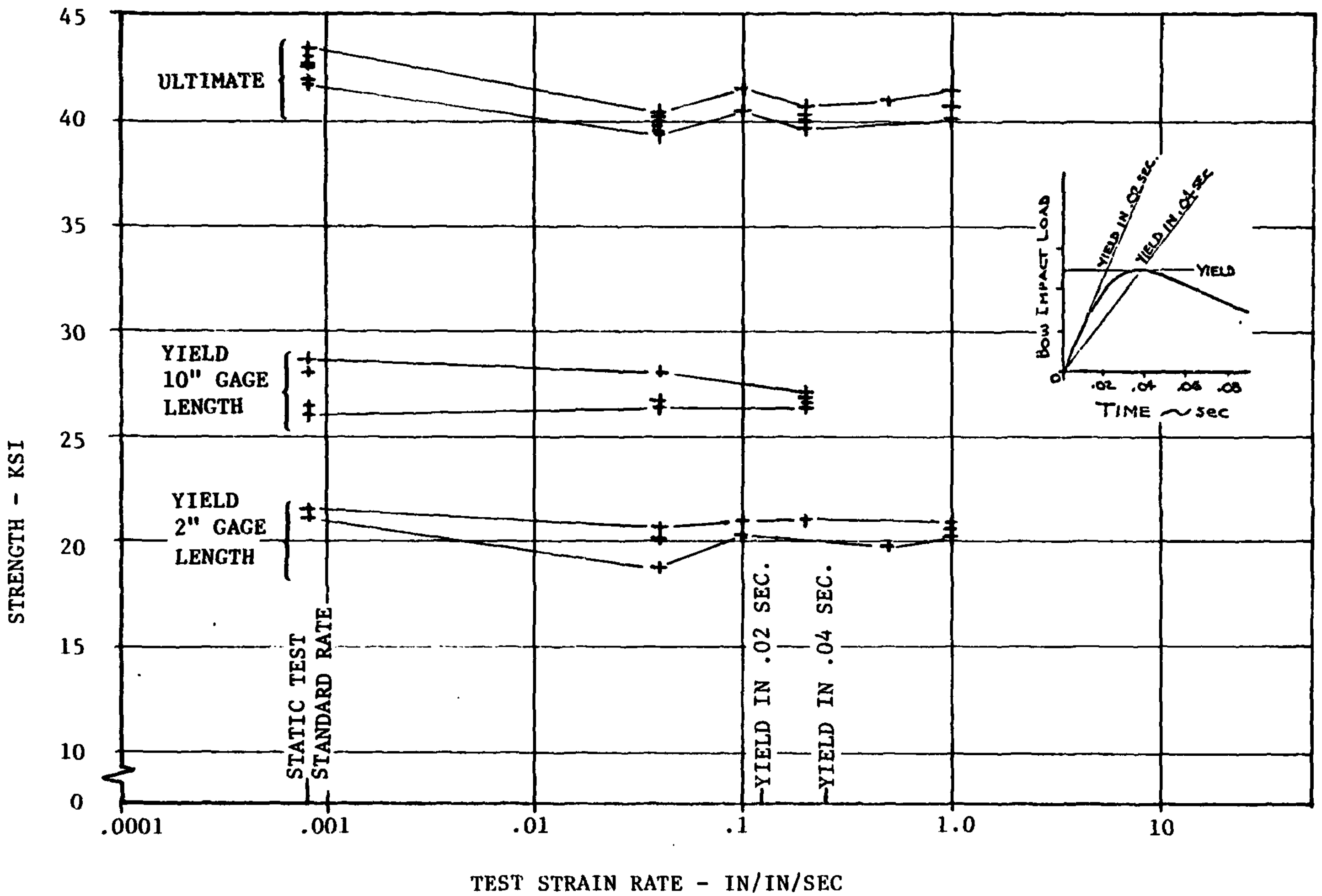


Figure 8-7. High Strain Rate Test Strength Data.

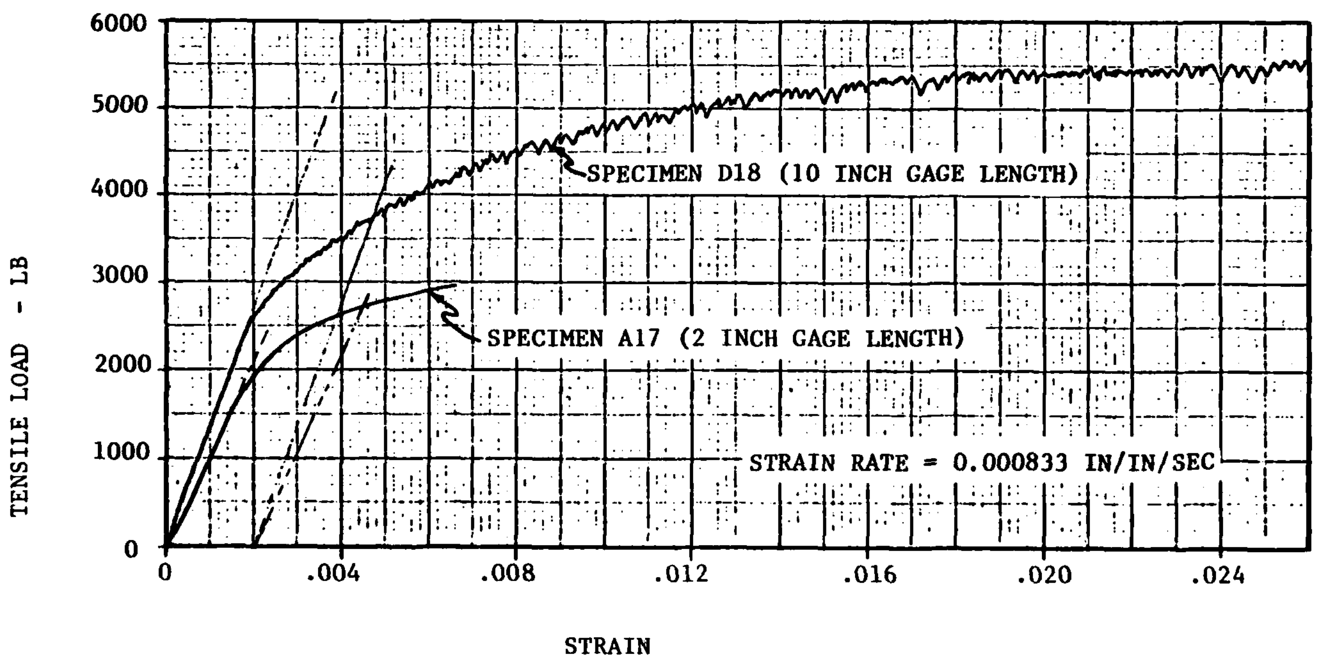


Figure 8-8. Typical Load - Strain Curves Recorded at Standard Static Test Strain Rates.

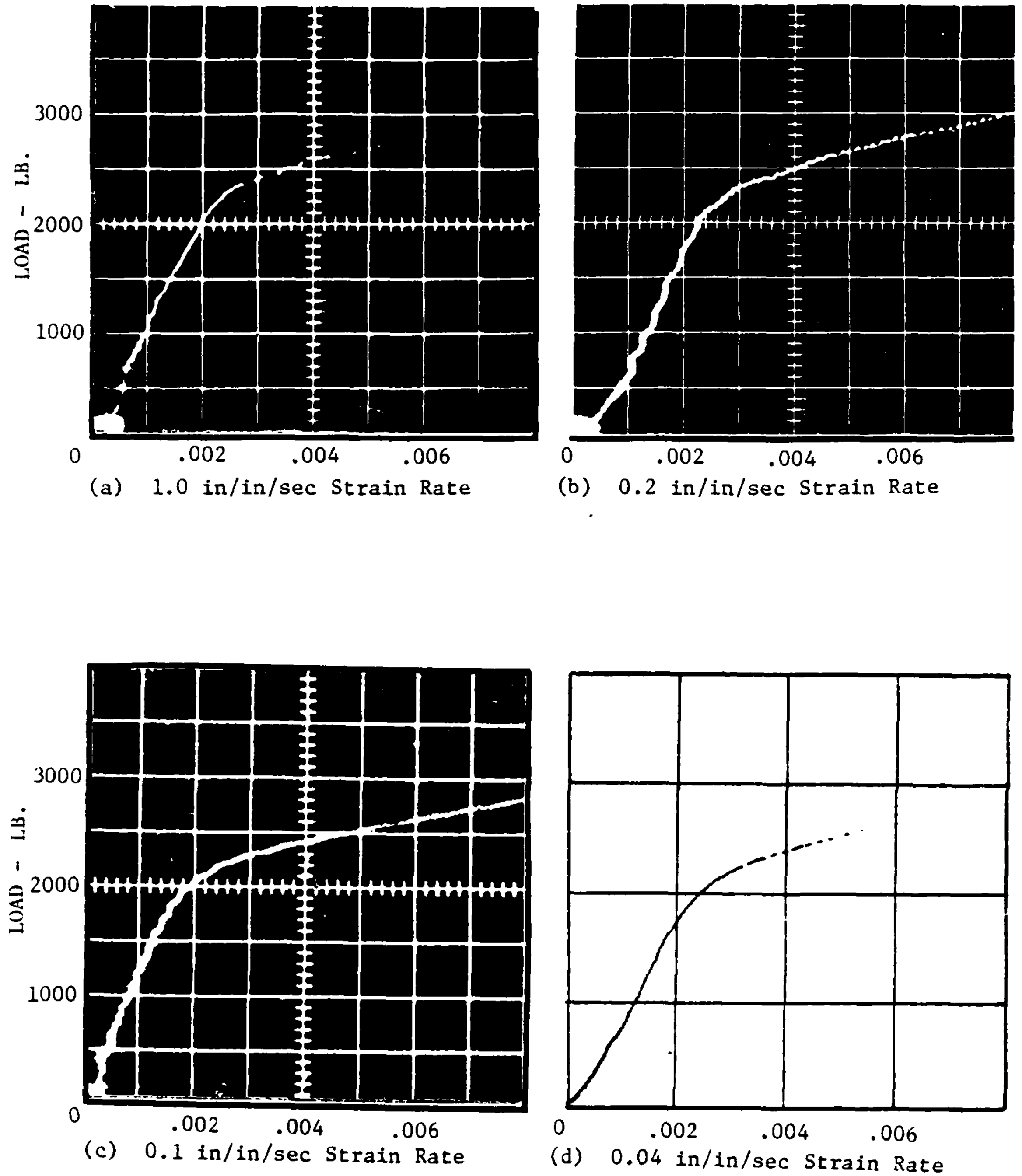
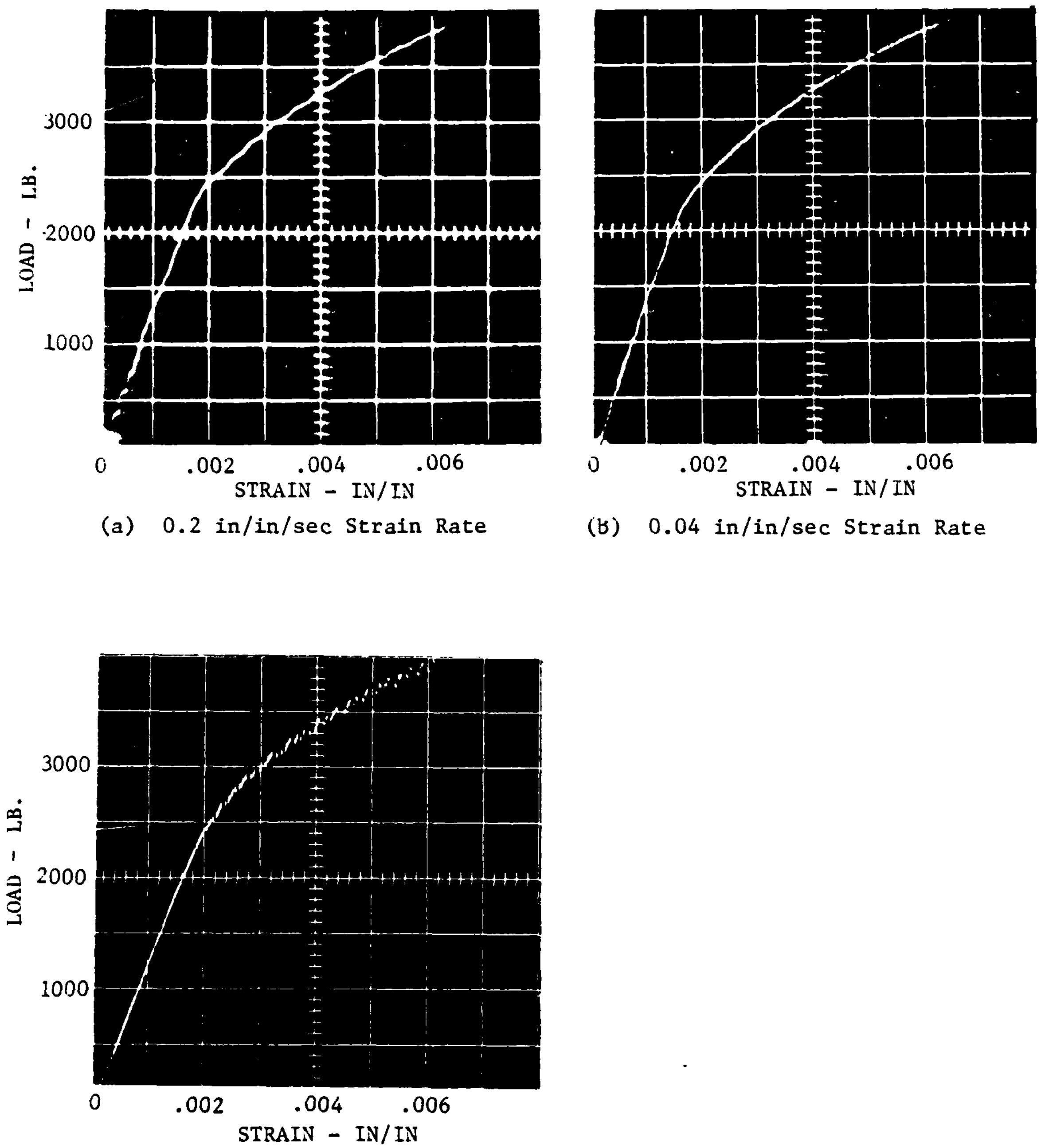


Figure 8-9. Typical Load-Strain Curves for 2-Inch Gage Length Specimens at Accelerated Strain Rates



(a) 0.2 in/in/sec Strain Rate

(b) 0.04 in/in/sec Strain Rate

(c) 0.000833 in/in/sec Strain Rate

Figure 8-10. Typical Load-Strain Curves for 10-Inch Gage Length Specimens at Accelerated Strain Rates

Post test examination of the failed specimens revealed that, in all cases, fracture occurred along a 45 degree plane through the specimen thickness. This plane traversed from the approximate center of the weld fusion area on the face side to the edge of the fusion zone on the root side. Examination under 10X magnification revealed the presence of some microporosity in the fracture surfaces, but no attempts were made to quantify the amounts. The weld fusion zone external surfaces exhibited pronounced "orange peel" texture and considerable necking. A band of reduced necking was evident in the heat affected zone extending approximately one-half inch beyond the boundary of the "orange peel" on each side of the weld joint.

8.3.7 CONCLUSIONS -- Based on the results of the high strain rate tests described above, transverse butt welded 5456 aluminum alloy plate exhibited no increases in yield strength or ultimate strength with increasing strain rates extending beyond the predicted 3KSES impulsive loading rates. In fact, slight decreases in these strength values, indicating a negative strain rate sensitivity were measured when test strain rates were increased from the standard static test rate (0.000833 per second) to a rate of 0.04 per second. Further increases in strain rate up to the maximum test rate of 1.0 per second produced no further change indicating an apparent lack of strain rate sensitivity.

8.4 KEEL CAP BLOCK BEARING TESTS

8.4.1 OBJECTIVE AND SCOPE -- In drydocking the 3KSES, the optimum arrangement for supporting the ship would be wood blocking piers spaced under the length of each sidehull heel. If proven feasible, this proposed arrangement would maximize access to the hull and minimize the quantity of blocking required.

The configuration of the sidehull fence caps which form the keel members on each side of the 3KSES is semi-cylindrical with a diameter varying from 3 inches near the bow to 12 inches at the stern. With blocking

positioned only under the sidehull keels, predicted cap block bearing stresses exceed those permitted by Reference 21 for more conventional
positioned only under the sidehull keels, predicted cap block bearing stresses exceed those permitted by Reference 21 for more conventional
hull forms and may cause excessive crushing of the cap blocks. A brief test program, as described below, was therefore implemented to acquire data for evaluating the proposed 3KSES drydock blocking arrangement.

The primary objective of these tests was to investigate the performance of both Douglas Fir and White Oak cap block timbers when loading in bearing by forms duplicating the maximum and minimum sidehull fence cap radii on the 3KSES. Tests were planned on timbers in the dry as-received condition and after 24 hours submergence in seawater. Test loads were planned to duplicate the maximum calculated knuckle loading as well as the calculated critical condition keel uniform loading. Specific data to be acquired included applied load versus deformation, deformation versus time for constant load, ultimate load at fracture and post-test permanent indentation measurements.

A complete matrix of the seven planned tests is presented in Table 8-4.

8.4.2 TEST SPECIMEN AND FIXTURE DESCRIPTIONS -- For the purposes of this investigation, only the cap block members were defined as test specimens. Each test specimen consisted of a pair of 6 x 10 x 30 inch long timbers which were marked to maintain serialized pair identity. Three such specimen pairs were Douglas Fir to be tested in the as-received condition. A fourth specimen pair was Douglas Fir to be tested after being submerged a minimum of 24 hours in seawater obtained from San Diego Bay. Three additional specimen pairs were White Oak; two of these were to be tested in the as-received condition and the third after a minimum of 24 hours submergence in seawater. Two additional 6 x 10 inch White Oak timbers 24 inches in length were employed as foundation members and were considered part of the test fixturing. These foundation members were used in the as-received

Table 8-4. 3KSES Docking Cap Block Bearing Test Matrix.

Test No.	Keel Radius		Cap Block Material		Cap Block Condition		Target Loading	
	6 in.	1 1/2 in.	Douglas Fir	White Oak	As Received	24-hour Soak	Running Load (lb/in.)	Total Load (lb.) ⚠2
1	X		X		X		5300 ⚠3	106,000
2 ⚠1	X		X		X		5300 ⚠3	106,000
3	X			X	X		5300 ⚠3	106,000
4	X			X		X	5300 ⚠3	106,000
5		X		X	X		3350 ⚠4	67,000
6		X	X		X		3350 ⚠4	67,000
7		X	X			X	3350 ⚠4	67,000

Notes: ⚠1 Load cycling test

⚠2 For 20-inch length of keel bearing

⚠3 Calculated maximum 3KSES knuckle block loading

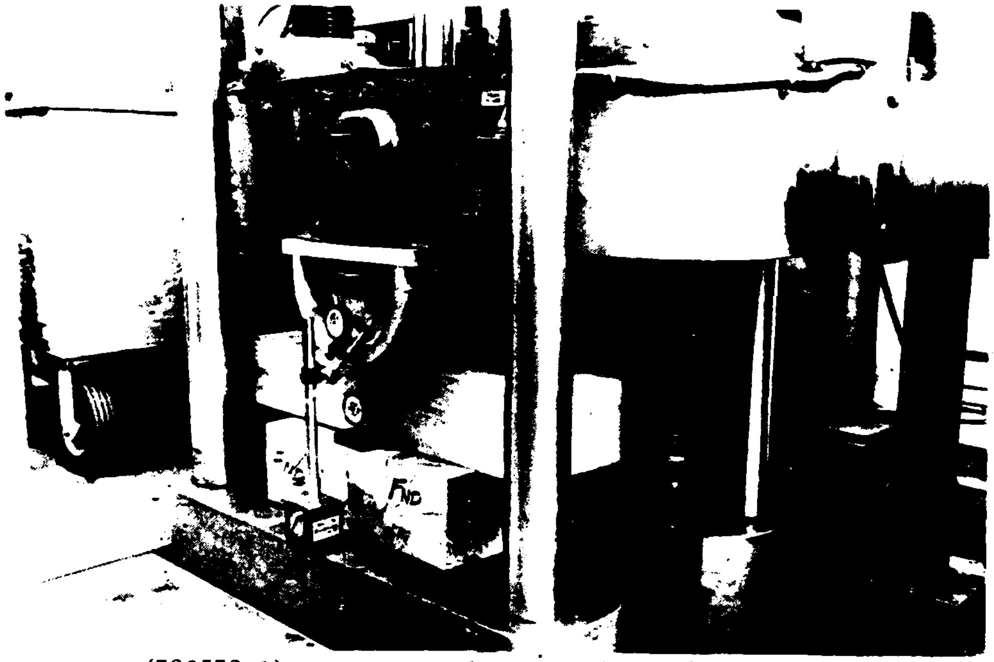
⚠4 Calculated maximum 3KSES uniform block loading (other than knuckle)

condition for all tests. Timber stocks for all of the above were purchased new to match the types and quality of wood regularly procured by various San Diego shipyards for use as blocking. Actual cross-section dimensions of the timbers as received were 5.5 by 9.5 inches for the Douglas Fir and 6.0 by 10.0 for the White Oak.

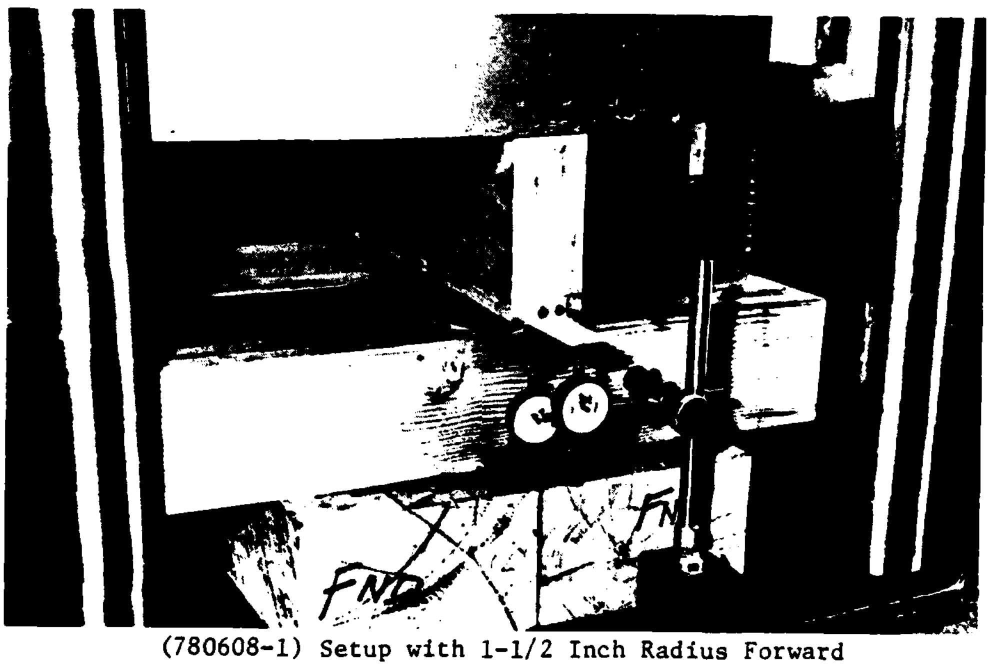
Two dummy keel forms were fabricated from aluminum per RMI Drawing No. TT801100 (Reference Appendix A) for use is applying the test loads to the cap block specimens. Both keel forms were semi-cylindrical in cross-section with a 24-inch length. The aft keel form (Assy No. TT801100-1) was fabricated with an outside radius of 6 inches; the forward keel form (Assy No. TT801100-5), with a radius of 1 1/2 inches. A fabricated aluminum spacer assembly was employed with the forward keel to provide adequate working clearance. A simple bearing plate was used with the aft keel form.

8.4.3 DESCRIPTION OF TEST SETUP -- All of the cap block bearing tests were conducted at the Rohr Industries Mechanical Test Laboratory using the 300,000 pound capacity Tinius Olsen Universal Testing Machine previously described in Section 4.4.1. Each test was wetup in this machine as shown in Figure 8-11(a) or (b). For each test, a serialized pair of test specimen cap block timbers was positioned at right angles atop the two oak foundation blocks centered on the test machine base. All timbers were placed withthe 6 inch cross section dimension normal to the base. The bearing plate for the aft keel form or the spacer assembly for the forward keel was attached to the test machine upper head oriented such that the keel axis would be aligned to the transverse centerline of the cap blocks. The appropriate keel form was then positioned across the cap blocks producing a nominal 20 inch length of bearing contact.

As shown in Figures 8-11(a) and (b), two dial deflection gages were positioned at each end of the keel form. These gages were set up to indicate the deformations of the cap blocks only as well as the combined deformations of the cap and foundation blocks.



(780578-1) Setup with 6-Inch Radius Aft Keel Form.



(780608-1) Setup with 1-1/2 Inch Radius Forward Keel Form

Figure 8-11. Keel Cap Block Bearing Test Setups

8.4.4 TEST PROCEDURES -- After the basic test setup was completed, shims were added between the test machine upper head and the bearing plate or spacer assembly as required to achieve uniform keel contact across the cap blocks. These shims were adjusted for each set of cap blocks tested.

Immediately prior to the start of loading, with slight clearance above the keel form, all dial gages were set to zero readings. Test loading was then applied according to prescribed schedules and loading rates. The loading schedules for all tests consisted of several phases performed in sequence as described below. Details of the schedule followed for each test are shown with the test results in Section 8.4.5.

Except for Test No. 2, loading during the initial phase was applied in 10,000 pound increments up to 67,000 pounds (equvalent to the calculated 3KSES maximum uniform keel block loading.) Loading was momentarily held at each increment for data reading and recording. In the second phase of all tests except Test No. 2, a load of 67,000 pounds was applied and maintained for 30 minutes. Data was recorded at intervals during this period. For tests using the forward keel form, loading was then incrementally increased from 67,000 pounds until major failure of the cap blocks occurred by splitting or crushing. Data was recorded at each increment. For those tests conducted with the aft keel form, loading was incrementally increased from 67,000 to 106,000 pounds (equivalent to the calculated 3KSES maximum knuckle block bearing load). The 106,000 pound load was then applied and maintained for periods ranging from 15 to 30 minutes. Data was again recorded at each increment and time interval. For the final phase of Test No. 4 using the aft keel form, loading was incrementally increased from 106,000 pounds until cap block failure occurred. In all of the above cases, the applied load was reduced to zero between successive phases to record permanent set data.

For the initial phase of Test No. 2, loading to 67,000 pounds was applied and released five times in succession followed by one load application to 106,000 pounds. These loads were applied and released at uniform rates with short holds only at the peak and zero points of each cycle to record data. Subsequent phases for Test No. 2 included a 30-minute hold at 106,000 pounds followed by incrementally increased loading to cap block failure.

In general, a loading rate of 5000 pounds per minute was employed. However, when prescribed loading increments were large and the effects of time were to be minimized, loading rates were selected to fully apply or release the load in approximately one minute.

Cap block indentation depth and width measurements were corded after all tests were completed.

8.4.5 TEST RESULTS -- The detailed loading schedules and the reduced deflection data from all seven cap block bearing tests are presented in Tables 8-5 through 8-11. Test observations and failure modes are also included in these tables.

The full history of applied load versus cap block penetrations depth for Test No. 2 is presented in Figure 8-12. The penetration depths plotted in this figure are the averages of the cap block deflection dial gage measurements obtained at each end of the keel form. From Figure 8-12, it is apparent that repeated applications of the calculated maximum uniform keel loading had little influence on the depth of cap block penetration. Application of the calculated knuckle loading initially increased the penetration depth approximately 50 percent to 0.64 inch. A repeat application of the knuckle loading, which was held for 30 minutes, increased the penetration depth to 0.82 inch. As loading was further increased, failure of the cap blocks by longitudinal splitting did not occur until the applied load reached 150 percent of the knuckle loading. Plots of cap block penetration depth versus

Table 8-5. Keel Cap Block Bearing Test No. 1 Data Summary.

Cap Blocks: Douglas Fir, As Received. **Keel Radius:** 6-inches.

Applied Load (kips)	Time at Load (min.)	Cap Block Deflect. (in.)		Combined Cap/Found. Block Deflect. (in.)		Remarks
		Near End	Far End	Near End	Far End	
0	-	0	0	0	0	
10	-	.051	.069	.065	.079	
20	-	.078	.104	.100	.119	
30	-	.105	.140	.134	.160	
40	-	.140	.185	.172	.209	"Snapping" noise
50	-	.181	.238	.219	.267	"Snapping" noises @ 45 and 47k
60	-	.232	.295	.271	.347	
67	-	.263	.333	.307	.369	
0	-	.139	.157	.157	.173	
67	0	.272	.344	.317	.379	
67	15	.313	.385	.361	.423	
67	30	.325	.397	.374	.436	
0	-	.203	.225	.224	.258	
70	-	.326	.396	.373	.435	
80	-	.355	.433	.405	.476	
90	-	.408	.498	.462	.540	
100	-	.487	.581	.544	.632	
106	0	.542	.637	.603	.687	Crack @ 102 kips
106	15	.658	.748	.723	.803	
0	0	.384	.383	.405	.403	

Table 8-6. Keel Cap Block Bearing Test No. 2 Data Summary.

Cap Blocks: Douglas Fir, As Received. Keel Radius: 6 inches.

Applied Load (kips)	Time at Load (min.)	Cap Block Deflect. (in.)		Combined Cap/Found. Block Deflect. (in.)		Remarks
		Near End	Far End	Near End	Far End	
0	-	0	0	0	0	
67	-	.380	.360	.398	.378	
0	-	.195	.211	.204	.217	
67	-	.384	.374	.420	.397	
0	-	.209	.222	.217	.229	
67	-	.392	.384	.434	.408	
0	-	.221	.236	.222	.257	
67	-	.398	.390	.441	.416	
0	-	.224	.242	.232	.250	
67	-	.402	.394	.444	.420	
0	-	.234	.248	.242	.263	
106	-	.652	.630	.690	.656	
0	-	.332	.363	.345	.372	
106	0	.685	.668	.745	.705	
106	5	.768	.741	.825	.783	
106	12	.797	.769	.856	.812	
106	20	.814	.785	.874	.829	
106	30	.830	.800	.890	.845	
0	-	.510	.530	.525	.550	
106	-	.828	.798	.885	.842	
106	-	- ⚠	- ⚠	.890	.850	
120	-	-	-	.920	.875	
140	-	-	-	1.023	.970	
160	-	-	-	1.240	1.275	Long. split in rear cap blk. @ 155K
180	-	-	-	1.460	1.430	

⚠ Dial deflection gages removed.

Table 8-7. Keel Cap Block Bearing Test No. 3 Data Summary.

Cap Blocks: Oak, As Received   Keel Radius: 6 inches

Applied Load (kips)	Time at Load (min.)	Cap Block Deflect. (in.)		Combined Cap/Found. Block Deflect. (in.)		Remarks
		Near End	Far End	Near End	Far End	
0	-	0	0	0	0	
10	-	.109	.047	.107	.057	
20	-	.138	.075	.147	.086	
40	-	.174	.125	.198	.143	
60	-	.210	.185	.245	.205	
67	-	.226	.205	.265	.230	
0	-	.093	.087	.093	.092	
67	0	.231	.215	.270	.240	
67	5	.245	.240	.287	.265	
67	10	.247	.243	.289	.268	
67	20	.254	.251	.297	.278	
67	30	.258	.256	.301	.284	
0	-	.145	.138	.150	.147	
60	-	.248	.245	.288	.270	
80	-	.268	.272	.313	.300	
100	-	.315	.332	.370	.365	
106	0	.342	.365	.399	.400	
106	5	.384	.414	.443	.449	
106	10	.396	.429	.457	.465	
106	20	.410	.445	.472	.482	
0	-	.212	.214	.224	.227	

Table 8-8. Keel Cap Block Bearing Test No. 4 Data Summary.

Cap Blocks: Oak, Soaked in Seawater. Keel Radius: 6 inches

Applied Load (kips)	Time at Load (min.)	Cap Block Deflect. (in.) Near End	Cap Block Deflect. (in.) Far End	Combined Cap/Found. Block Deflect. (in.) Near End	Combined Cap/Found. Block Deflect. (in.) Far End	Remarks
0	-	0	0	0	0	
10	-	.041	.099	.061	.095	
20	-	.077	.183	.076	.180	
40	-	.137	.252	.170	.268	
60	-	.189	.307	.226	.328	
67	-	.211	.325	.250	.350	
0	-	.067	.085	.080	.085	
67	0	.220	.330	.259	.355	
67	5	.245	.346	.286	.374	
67	10	.251	.351	.293	.380	
67	20	.259	.359	.301	.387	
67	30	.264	.363	.307	.392	
0	-	.110	.136	.125	.140	
60	-	.250	.344	.288	.370	
67	-	.264	.357	.304	.385	
80	-	.278	.376	.320	.406	
100	-	.321	.422	.366	.460	
106	0	.350	.455	.400	.495	
106	5	.398	.500	.451	.541	
106	10	.411	.513	.466	.555	
106	20	.427	.526	.481	.568	
0	-	.190	.205	.212	.210	
100	-	.409	.503	.460	.545	
106	-	.428	.517	.479	.560	
120	-	.445	.535	.498	.570	
140	-	.482	.593	.547	.640	
160	-	.552	.670	.624	.720	
180	-	.636	.765	.721	.820	
200	-	.774	.910	.875	.970	
209	-	.878	1.010	.988	-	
↓	-	△1	△1	△1	△1	
300	-	-	-	-	-	Test machine load limit; no failure.

△1 Dial deflection indicator removed.

Table 8-9. Keel Cap Block Bearing Test No. 5 Data Summary.

Cap Blocks: Oak, As Received   Keel Radius: 1½ inches

Applied Load (kips)	Time at Load (min.)	Cap Block Deflect. (in.)		Combined Cap/Found. Block Deflect. (in.)		Remarks
		Near End	Far End	Near End	Far End	
0	-	0	0	0	0	
10	-	.032	.075	.055	.085	
20	-	.064	.104	.091	.121	
30	-	.095	.132	.127	.157	
40	-	.133	.168	.173	.199	
50	-	.172	.208	.216	.242	
60	-	.216	.253	.265	.291	
67	-	.252	.288	.303	.327	
0	-	.122	.153	.140	.155	
67	0	.260	.295	.310	.335	
67	5	.288	.323	.342	.365	
67	10	.295	.331	.351	.373	
67	20	.304	.341	.361	.384	
67	30	.311	.347	.368	.390	
0	-	.188	.207	.215	.212	
67	-	.307	.341	.364	.384	
80	-	.326	.364	.388	.410	
100	-	.398	.435	.462	.485	Slight "cracking" noises
120	-	.503	.550	.588	.610	
140	-	.638	.692	.725	.752	
160	-	.775	.840	.868	.900	
180	-	- 1	- 1	- 1	- 1	
185	-	-	-	-	-	Midplane long. shear split
200	-	-	-	-	-	Maximum load applied

1 Dial deflection gage removed.

Table 8-10. Keel Cap Block Bearing Test No. 6 Data Summary.

Cap Blocks: Douglas Fir, As Received, **Keel Radius:** 1 ½ inches

Applied Load (kips)	Time at Load (min.)	Cap Block Deflect. (in.)		Combined Cap/Found. Block Deflect. (in.)		Remarks
		Near End	Far End	Near End	Far End	
0	-	0	0	0	0	
10	-	.041	.059	.056	.081	
20	-	.102	.112	.123	.145	Slight "cracking" noises
30	-	.184	.195	.211	.233	
40	-	.260	.278	.290	.320	
50	-	.360	.389	.392	.437	
60	-	.478	.520	.515	.575	
67	-	.567	.620	.609	.675	
0	-	.372	.355	.372	.370	
67	0	.630	.660	.672	.715	
67	5	.703	.740	.747	.795	
67	10	.721	.763	.767	.819	
67	20	.745	.789	.792	.846	
67	30	.761	.806	.808	.863	
0	-	.523	.482	.511	.507	
67	-	.762	.788	.807	.843	
80	-	.815	.845	.861	.900	
100	-	- ⚠1	- ⚠1	- ⚠1	- ⚠1	
122.5	-	-	-	-	-	Long. shear split in rear cap block.

⚠1 Dial deflection gage removed.

Table 8-11. Keel Cap Block Bearing Test No. 7 Data Summary.

Cap Blocks: Douglas Fir, Soaked in Seawater. **Keel Radius:** 1 ½ inches.

Applied Load (kips)	Time at Load (min.)	Cap Block Deflect. (in.)		Combined Cap/Found. Block Deflect. (in.)		Remarks
		Near End	Far End	Near End	Far End	
0	-	0	0	0	0	
10	-	.127	.116	.149	.121	
20	-	.217	.220	.245	.230	Cracking noises
30	-	.324	.330	.356	.347	
40	-	.449	.457	.489	.478	Localized splintering
50	-	.590	.602	.635	.625	Substantial cracking noises
60	-	.770	.792	.820	.820	
67	-	.887	.915	.942	.945	
0	-	.380	.430	.400	.410	
67	0	.970	1.000	.995	1.005	
67	5	-⚠	-⚠	1.021	1.032	
67	10	-	-	1.039	1.049	
67	20	-	-	1.062	1.072	
67	30	-	-	1.079	1.087	
0	-	-	-	-	-	
67	-	-	-	1.065	1.083	
80	-	-	-	1.131	1.155	
100	-	-	-	1.501	1.530	Long. Shear split in front cap block; water on sides of cap blocks

⚠ Dial deflection gage removed

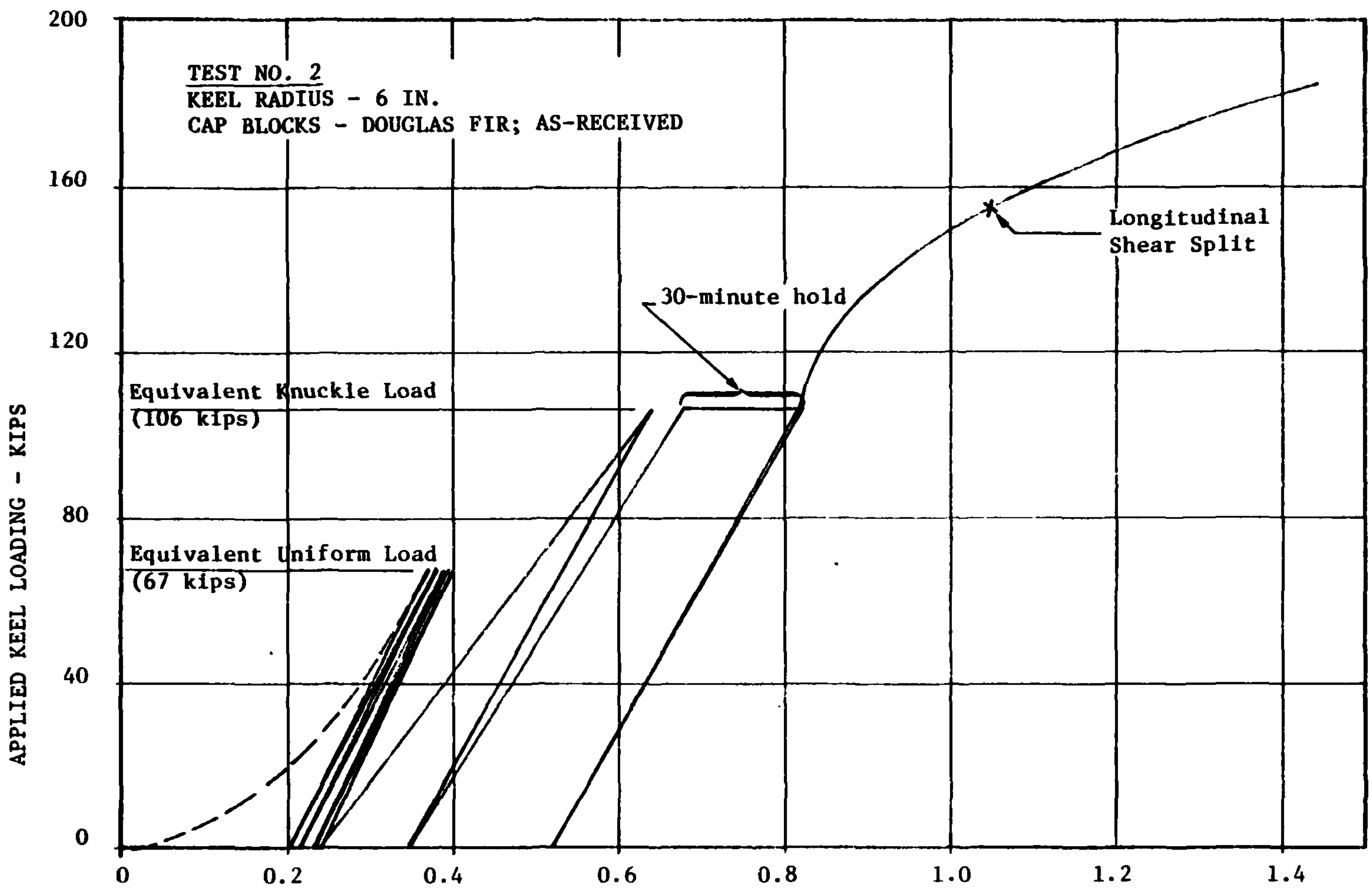


Figure 8-12. Cap Block Test Load - Penetration History.

applied load for the tests conducted with the 6 inch radius aft keel form are presented in Figure 8-13. Similar plots for the tests conducted with the 1-1/2 inch radius forward keel form are shown in Figure 8-14. In both Figures 8-13 and 8-14, the plotted curves represent the average of the penetration depth measurements obtained at each end of the keel form. The curves have also been adjusted to eliminate the penetration depth increment produced during each cycle of unloading to obtain permanent set data.

From Figure 8-13 it can be seen that the performance of dry Douglas Fir was nearly identical to that of soaked White Oak when each was subjected to the maximum keel uniform loading. After one-half hour, average penetration depths were approximately 5/16 inch. Under the knuckle block loading, soaked White Oak showed approximately 10 percent more penetration depth than dry White Oak, but average penetration depths for both remained below 1/2 inch. With dry Douglas Fir, the penetration depth caused by knuckle loading was slightly more than 11/16 inch. The dry Douglas Fir cap blocks subsequently sustained a loading of 7,750 pounds per inch of bearing length, or nearly 50 percent above the knuckle block loading, before significant longitudinal fracturing occurred. By contrast, the White Oak cap blocks which had been soaked in seawater sustained more than 15,000 pounds per inch without fracture or significant crushing.

From the results presented in Figure 8-14 for the 1-1/2 inch radius keel form, it can be seen that the cap block average penetration depths under the maximum uniform keel loading reached approximately 5/16, 3/4, and 1 inch for dry White Oak, dry Douglas Fir and soaked Douglas Fir, respectively. Taken in the same order, significant longitudinal fractures occurred in the cap blocks at applied loads which were 200 percent, 80 percent, and 50 percent above the maximum calculated uniform keel block loading. Phtotgraphs illustrating fracture and crushing of the dry Douglas Fir cap blocks, when loaded to failure with the 1-1/2 inch radius keel are shown in Figure 8-15.

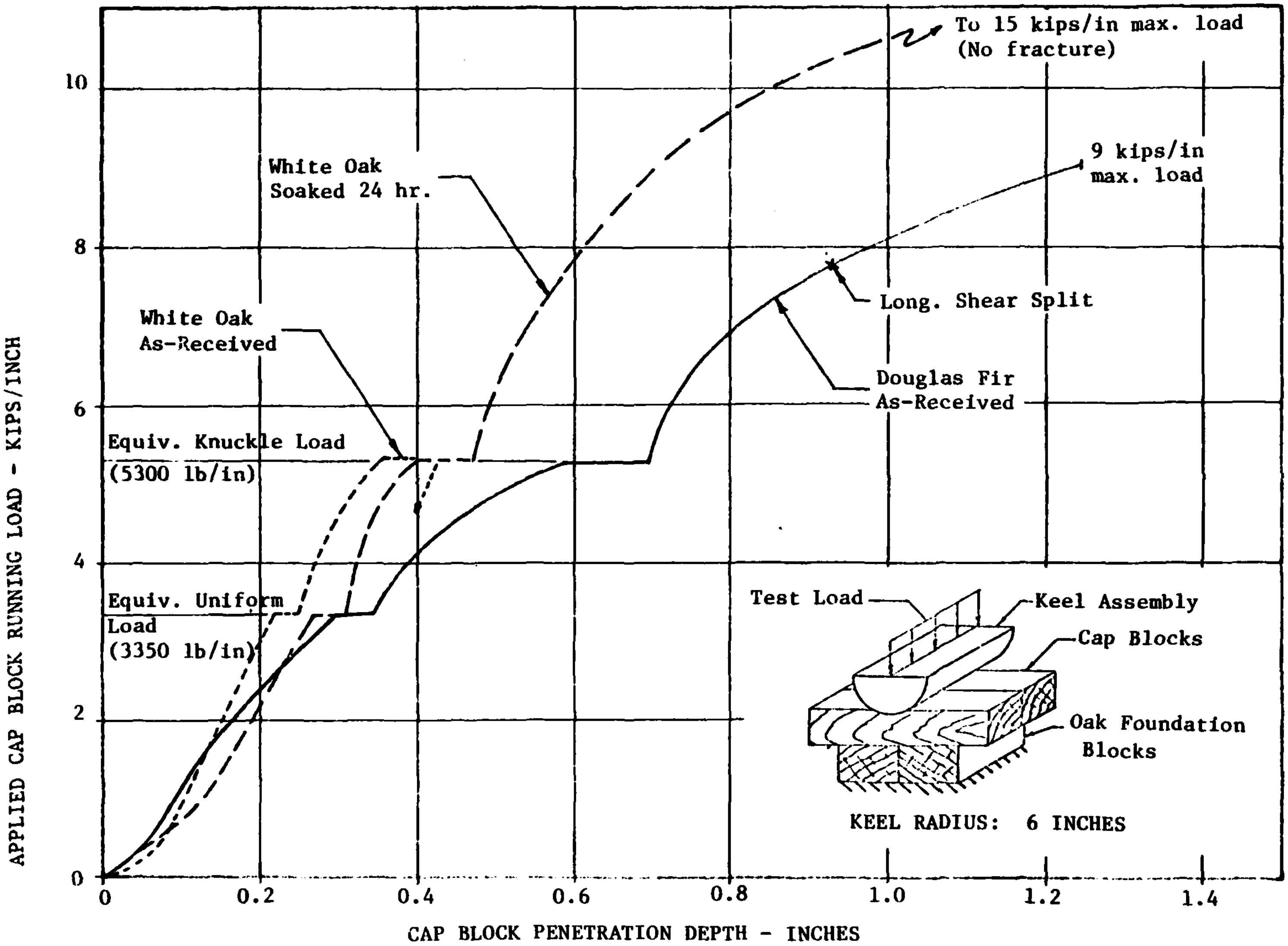


Figure 8-13. Cap Block Bearing Test Results with 6-Inch Radius Keel.

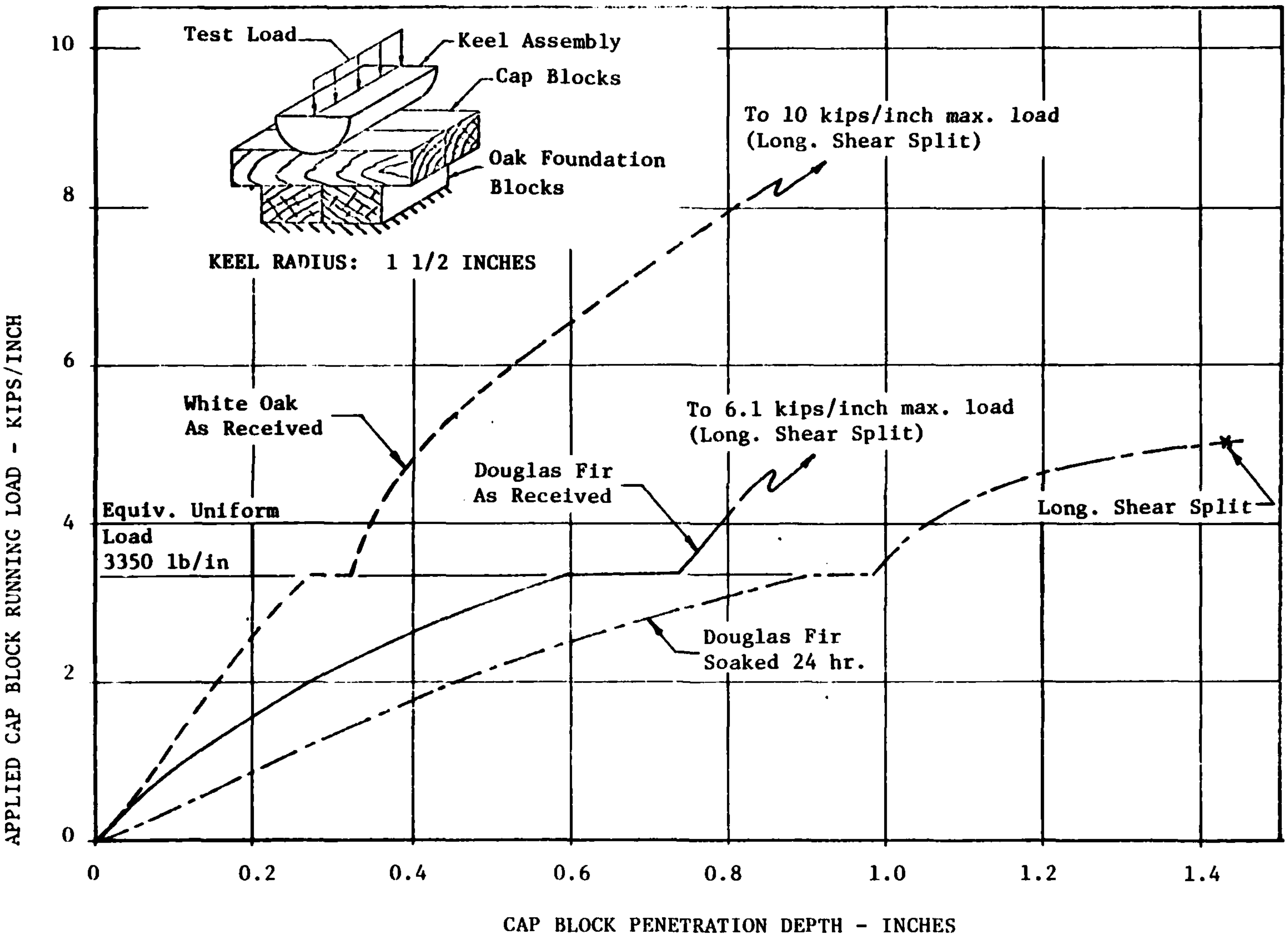
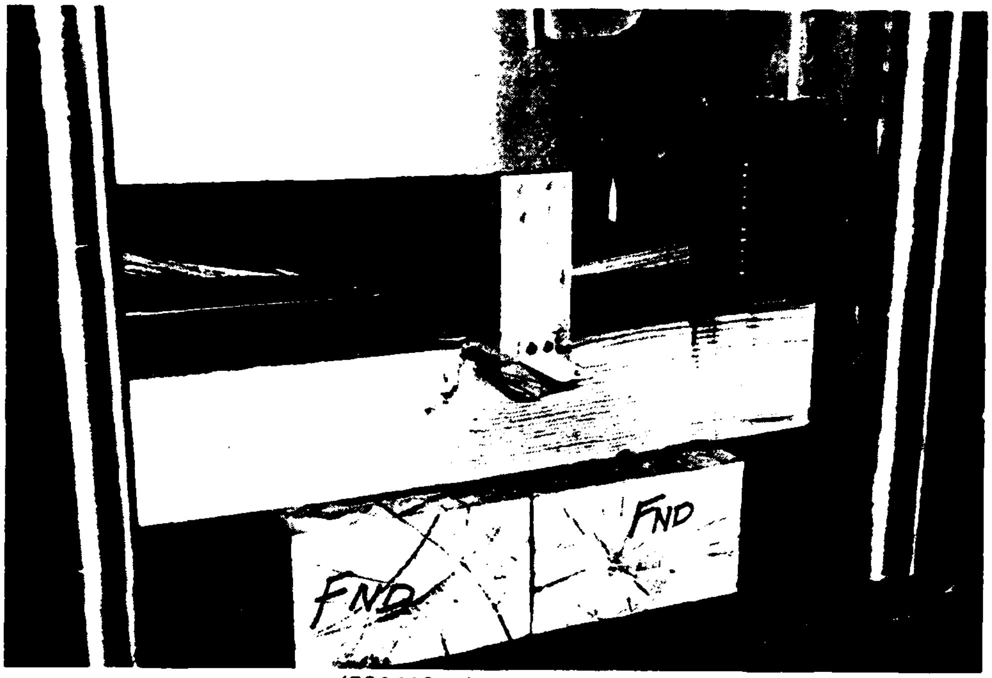


Figure 8-14. Cap Block Bearing Test Results with 1 1/2 - Inch Radius Keel.



(780608-2) Front View

(780608-3) Rear View

Figure 8-15. Dry Douglas Fir Cap Block Failures with 129,000 Pound Load on 1-1/2 Inch Radius Keel

Curves depicting the measured increases in cap block penetration depth under sustained constant loading for the conditions tested are presented in Figure 8-16. From these curves, it is evident that the rate of increase in penetration depth declines asymptotically with elapsed time. However, for two of the conditions tested, measured penetration depths were approaching stability at the end of the relatively short 30-minute period during which data were recorded.

A photograph illustrating the post-test permenent indentations in all seven of the cap block specimen pairs is shown in Figure 8-17. Measurements of the indentation depths and widths are presented in Table 8-12.

8.4.6 CONCLUSIONS -- Based on the results of the keel bearing tests described above, cap blocks of both White Oak and Douglas Fir demonstrated bearing capacities exceeding calculated requirements for the 3KSES. For the aft knuckle area, White Oak cap blocks proved capable of sustaining nearly triple the calculated maximum load requirements without fracture or excessive crushing. For the same application, dry Douglas Fir cap blocks exceeded requirements by only 50 percent before significant fracturing occurred. In addition, the effect of 24-hour soak was to increase penetration depths by 1/6 inch or less.

The keel bearing test results also demonstrated that only White Oak cap blocks were acceptable for use under the forward portion of the ship where the keel radius was as small as 1-1/2 inches. However, for the major portion of the 3KSES keel length from the knuckle area forward, the tests showed that Douglas Fir cap blocks would combine large reserve bearing capacity with higher compliance to better equalize bearing load distribution along the keel length. The location at which the diminishing keel radius would require a transition from Douglas Fir to White Oak cap blocks was not established.

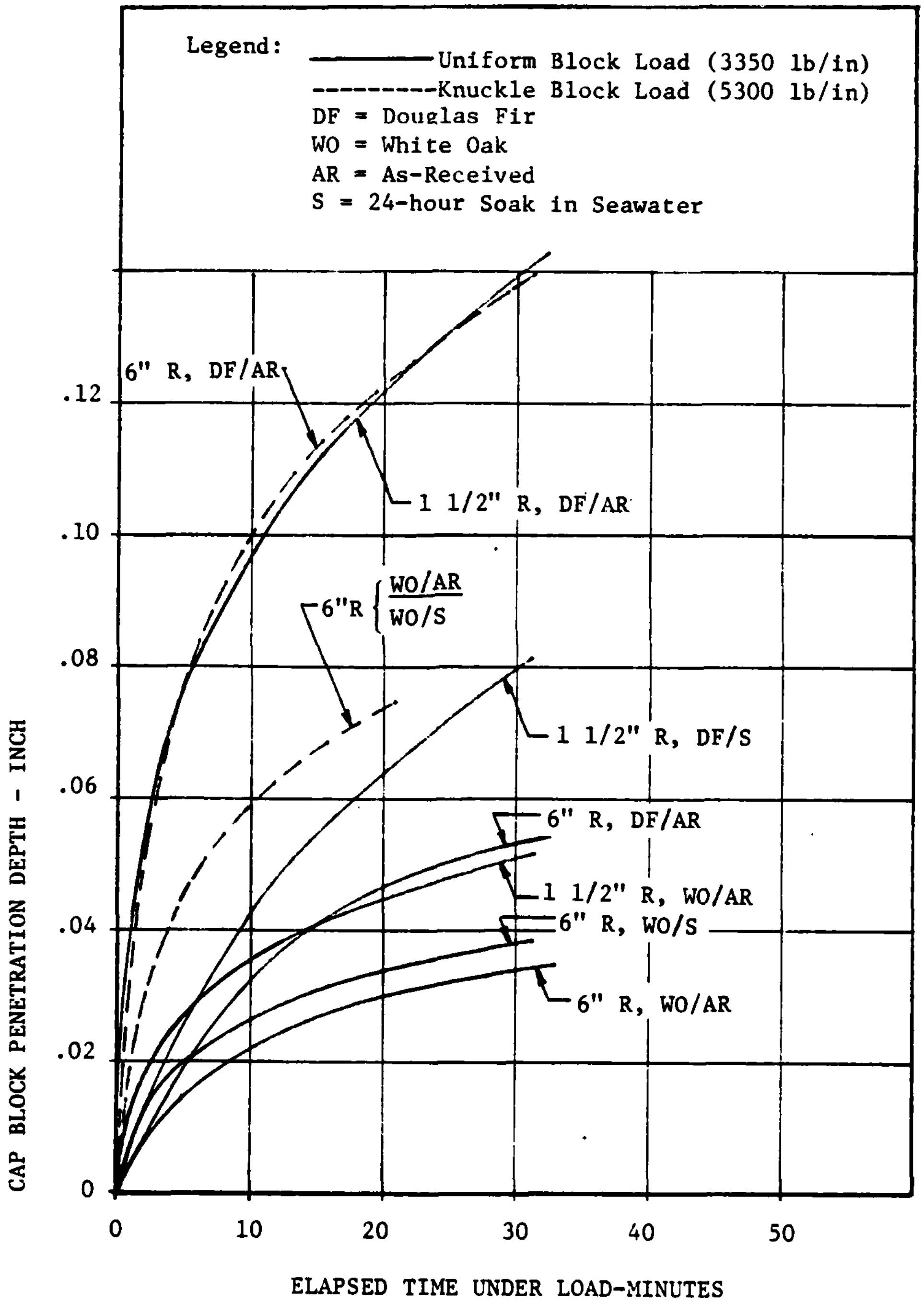
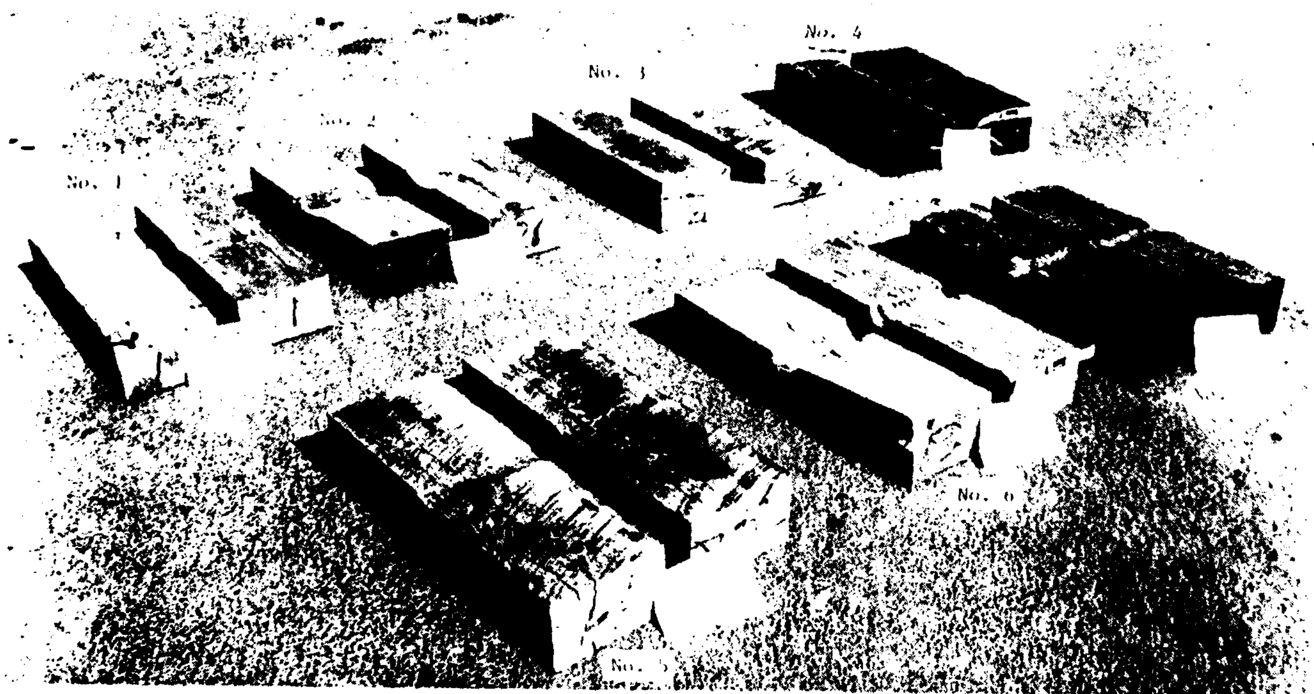


Figure 8-16. Cap Block Penetration Depth vs. Time Under Load.



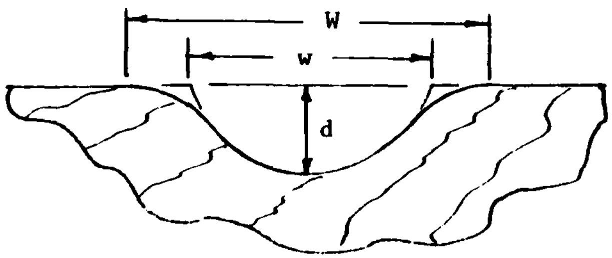
6" Radius Keel: No. 1 & 2 - Douglas Fir, Dry; No. 3 - White Oak, Dry; No. 4 - White Oak, Soaked.
1½" Radius Keel: No. 5 - White Oak, Dry; No. 6 - Douglas Fir, Dry; No. 7 - Douglas Fir, Soaked.

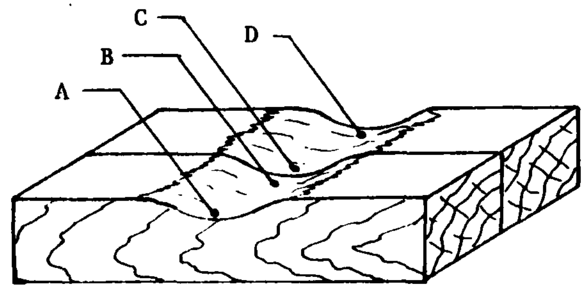
Figure 8-17. (780650-1) Post - Test View of All Cap Block Specimens.

Table 8-12. Cap Block Post-Test Indentation Measurements

Keel Radius (in)	Cap Block Description	Maximum Applied Test Load (kips)	Measurement Location											
			A			B			C			D		
			d (in)	w (in)	W (in)	d (in)	w (in)	W (in)	d (in)	w (in)	W (in)	d (in)	w (in)	W (in)
6	D.Fir-AsRcvd	106	.18	4.3	5.35	.26	4.45	5.9	.40	4.85	6.1	.25	4.45	4.9
6	D.Fir-AsRcvd	180	.52	6.85	6.85	.83	6.95	8.5	.72	6.87	6.87	.76	7.0	7.5
6	W.Oak-AsRcvd	106	.08	2.57	2.57	.09	2.80	2.80	.12	3.17	3.17	.13	3.35	3.35
6	W.Oak-Soaked	300	.22	5.55	5.95	.28	5.8	6.35	.22	5.8	~6.0	.25	6.0	6.5
1½	W.Oak-AsRcvd	200	.40	2.75	2.75	.44	2.80	3.7	.32	2.35	4.6	.30	2.3	4.9
1½	D.Fir-AsRcvd	122.5	1.33	3.2	3.2 4.2*	1.26	3.2	3.2	1.34	3.3	3.3	.99	3.3	3.3 5.2*
1½	D.Fir-Soaked	100	.41	2.8	6.0	.75	2.75	5.6	.74	3.0	3.7	.94	3.0	4.25

* Measurement made approximately midway across block.





From the above, it can be concluded that appropriate positioning of a combination of White Oak and Douglas Fir cap blocks along the length of the 3KSES keels would sustain the maximum calculated 3KSES docking loads with sufficiently large reserve capacity. Therefore, the proposed optimum arrangement of blocking under the 3KSES sidehull keels only has been proven feasible with regard to cap block bearing strength considerations.

9 / REFERENCES

The following references are cited by number throughout this document:

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2) Structural Element Test Plan, RMI Document No. TTP00017, CDRL E064, April 1978.

3) 3KSES Production Plan, Appendix A, Hull Structure Fabrication, Revision B, RMI Document No. TPP002B, CDRL E00K(A), September 1979.

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11) Metals; Test Methods, Federal Test Method Standard No. 151a, May 1959.

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APPENDIX A / DRAWINGS

This appendix contains copies of all drawings prepared to meet requirements of the Panel and Element Structural Test Program. Drawings defining the test specimen fabrication assemblies, individual test specimens, and specially developed test fixturing are included as listed below.

The interrelationships of all structural panel drawings, structural element drawings, and the associated fixturing drawings are charted in Figure A-1 which follows the drawing listings.

A.1 ROHR MARINE INC. DRAWINGS

A.1.1 FABRICATION ASSEMBLY AND TEST SPECIMEN DRAWINGS

DRAWING NUMBER	REVISION LETTER	NUMBER OF SHEETS	DRAWING TITLE
TT802015	A	2	Plate Weldments, Transverse Butt, Structural Test
TT802016	A	1	Test Specimens - Welded Plate, Static Test
TT802017	A	1	Plate Weldments, Transverse Cruciform, Structural Test
TT802018	A	1	Plate Weldments, Transverse Tee, Structural Test
TT802019	A	1	Test Specimens - Welded Plate Tensile Fatigue Test
TT802020	A	1	Test Specimens - Welded Plate Bending Fatigue Test

DRAWING NUMBER	REVISION LETTER	NUMBER OF SHEETS	DRAWING TITLE
TT802021	A	1	Plate Weldments, Transverse Butt Weld Imperfections, Structural Test
TT802022	A	2	Test Article Assembly - Stiffened Panel, Tensile Static and Fatigue Tests
TT802023	A	2	Test Article Assembly - Stiffened Panel, Compression Buckling Test
TT802024	A	5	Fabrication Assembly - Flatbar Stiffened Panels, Structural Test
TT802032	--	1	Fabrication Assembly - Deck/Bulkhead Intersection, Structural Element Test
TT802033	--	1	Test Article Assemblies - Deck/Bulkhead Intersections, Tensile, Static and Fatigue Tests
TT802041	--	1	Test Article Assemblies - 3-Bay Panel Element, Combined Loading Tests
TK801021	--	1	Welded Plate Assembly/Specimens, Dynamic Strength Tests

A.1.2 FIXTURE DRAWINGS

DRAWING NUMBER	REVISION LETTER	NUMBER OF SHEETS	DRAWING TITLE
TT110001	--	1	Full Size Template, Bowed Flatbar
TT801100	--	1	Keel Assemblies, Cap Block Loading Tests, 3KSES Drydocking
TT802014	A	1	Test Fixture and Installation - Compression (Modification)
TT802025	--	2	Test Fixture (Modification), Tensile Static and Fatigue Stiffened Panel
TT802028	--	1	Tooling Holes Drill Fixture
TT802029	--	2	Specimen Drill Fixture
TT802042	--	1	Rod Eye and Stud, Structural Test - 3KSES

A.2 ROHR INDUSTRIES INC. DRAWINGS

DRAWING NUMBER	REVISION LETTER	NUMBER OF SHEETS	DRAWING TITLE
501-392	--	3	3KSES Program, Three-Bay Panel Element Test Fixture

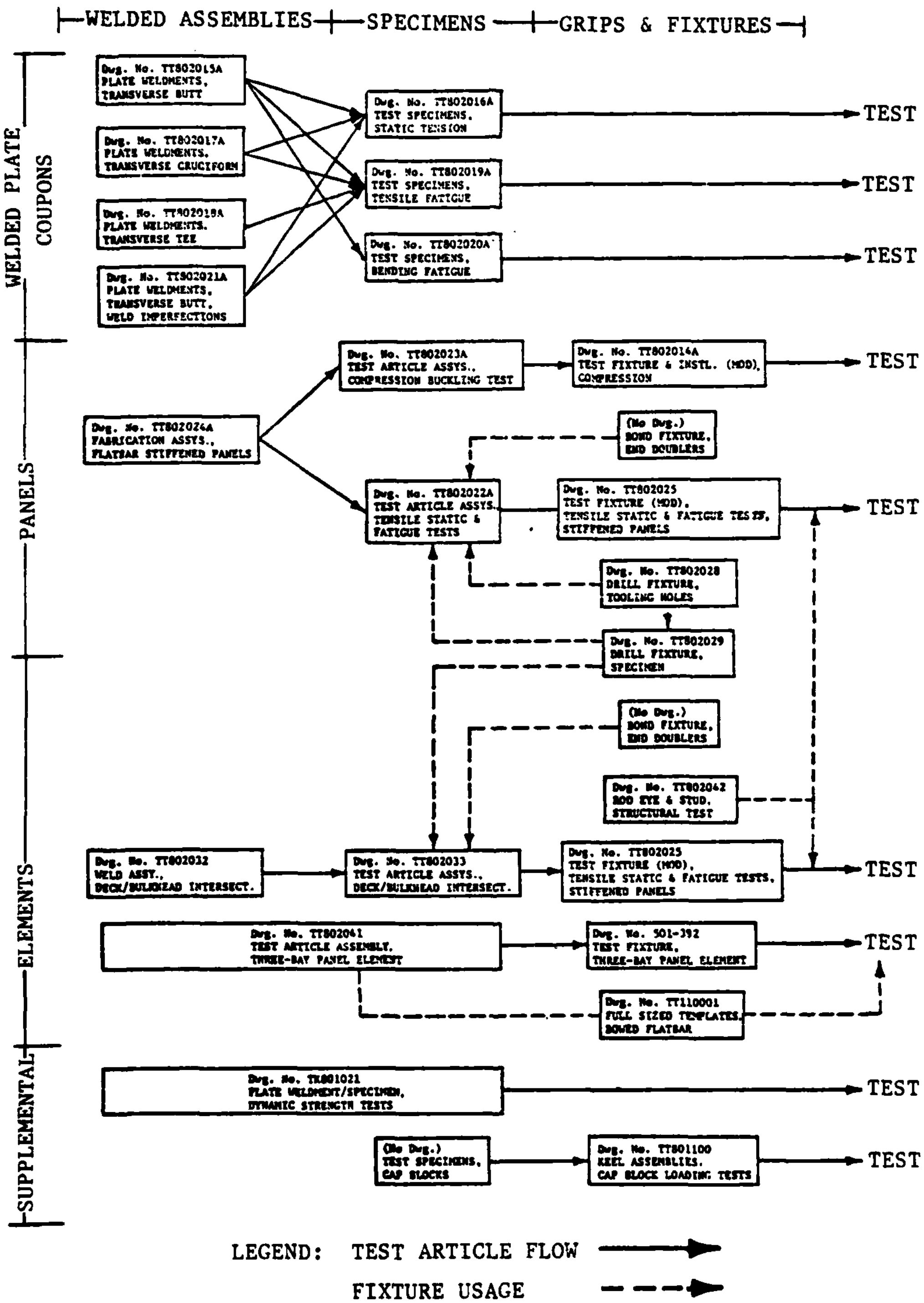

Figure A-1. Drawing Correlation Diagram - Panel and Element Test Program.

21. PRIOR TO WELDING, LIGHTLY CONTAMINATE WELD REPAIR ZONES INDICATED WITH KEROSENE TO CREATE WELD DEFECTS. COORDINATE WITH COGNIZANT ENGINEER.

QUANTITY REQUIRED PER ASSY

2

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… CONTAMINATE WELD REPAIR ZONES
…NE TO CREATE WELD DEFECTS.
…IZANT ENGINEER.

(NOTES CONT'D)

15 PEEN SURFACES OF WELD BEADS OVER FULL LENGTH AND SUFFICIENT WIDTH TO COVER HEAT AFFECTED ZONES ON BOTH SIDES. PEENING INTENSITY TO BE .004 TO .008 ALMEN A ARC HEIGHT. PEENING TO BE PEFORMED AFTER ALL WELDING, REPAIR WELDING, BEAD FAIRING, BEAD SHAVING AND PANEL STRAIGHTENING OPERATIONS HAVE BEEN COMPLETED AND INSPECTED

16 PEENING METHOD TO BE ROTARY FLAPPER PEENING.

17 PEENING METHOD TO BE SHOT PEENING.

18 PEENING METHOD TO BE SPECIFIED BY STRUCTURES ENGINEERING

19 FAIR FRONT AND BACK WELD BEAD REINFORCEMENTS TO A SMOOTH CONTOUR, BLENDING INTO BASE METAL ON BOTH SIDES OF JOINT. DO NOT GRIND. FINISH OF FAIRED BEAD TO BE 125 OR BETTER. FAIRING OPERATION TO BE PERFORMED AFTER ALL WELDING AND ANY REPAIR WELDING AND INSPECTIONS ARE COMPLETED, AND PRIOR TO ANY PEENING

20 WELD SYMBOL FRACTIONAL DIMENSIONS SHOWN ARE MINIMUM.

(NOTES CONT'D)

· MAKE WELD REPAIRS BY GRINDING OUT SEGMENTS OF WELD BEAD AS REQUIRED TO REMOVE DEFECTIVE WELD AND REWELDING PER QUALIFIED REPAIR WELD PROCEDURES. DOCUMENTED VISUAL AND PENETRANT INSPECTIONS ARE REQUIRED BEFORE AND AFTER REPAIR WELDING. USE GROUP III LIQUID PENETRANT ONLY.

AFTER COMPLETING WELD REPAIR REQUIREMENTS PER 13, SIMULATE REPEATED WELD REPAIRS BY GRINDING OUT SEGMENTS OF WELD BEAD INDICATED BY "◇" ON F/D AND REWELDING PER QUALIFIED REPAIR WELD PROCEDURES. LENGTH DIMENSIONS SHOWN ON F/D APPLY TO COMPLETED REPAIR WELD BEAD. SIMULATE ADDITIONAL WELD REPAIRS INDICATED BY "✳" ON F/D IN A SIMILAR MANNER. DOCUMENTED VISUAL AND DYE PENETRANT INSPECTIONS ARE REQUIRED BEFORE AND AFTER "◇" REPAIR WELDING AND AFTER "✳" REPAIR WELDING.

(NO…

QUANTITY REQUIRED PER ASSY	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
	-815	2/D7	PLATE	5456 H116/H117 AL ALY	.750 X 12.0 X 24.0	QQ-A 250/20	
	-811	2/D7	PLATE	5456 H116/H117 AL ALY	.500 x 12.0 x 24.0	QQ-A 250/20	
	-807	2/D8	PLATE	5456 H116/H117 AL ALY	.375 x 12.0 x 24.0	QQ-A-250/20	
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	-805	2/D7	PLATE	5456 H116/H117 AL ALY	.313 x 12.0 x 24.0	QQ-A 250/20	
	-705	3/C6	WELD ASSY				15 16
	-701	3/C6	WELD ASSY				
	-509	2/C6	WELD ASSY				
	-505	2/C6	WELD ASSY				15 16
	-501	2/C6	WELD ASSY				
	-411	3/C7	WELD ASSY				
	-407	3/C7	WELD ASSY				15 16 19
	-405						15 16
	-403						
	-401	2/C7	WELD ASSY				
	-343	2/B8	WELD ASSY				
	-339	2/C6	WELD ASSY				15 16
	-337	2/B7	WELD ASSY				15 16
	-333	2/B7	WELD ASSY				
	-331	2/C6					15
	-329	2/B7					15 17
	-327	2/C6					15 16
	-325	2/B7					15 16
	-323	2/B7					
	-321	2/B7					
	-319	2/C7					
	-317						
	-315						
	-313						15 16
	-311						
	-309						
	-307						15 17
	-305						15 16
	-303						
	-301	2/C7	WELD ASSY				

PARTS LIST (CONT'D)

TT802015 A

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NOTES:

1. BREAK A... ARP EDGES
2. UNLESS OTHERW SE SPECIFIED, AL FABRICATION, WELDING AND INSPECTION BE PER NAVSEA 0900-LP-060-4010
3. WELD SYMBOLS PER AWS-A-2.0. *EXCEPT AS NOTED, ALL WELDING TO BE* ACCOMPLISHED PER PROCEDURES QUALIFIED FOR 3KSES PRODUCTION OF THE SAME JOINT CONFIGURATION.
4. WELD REPAIRS *OTHER THAN THOSE SPECIFIED ARE NOT PERMITTED* WITHOUT SPECIFIC STRUCTURES ENGINEERING APPROVAL
5. COGNIZANT STRUCTURES ENGINEER TO WITNESS FIRST ARTICLE WELDING AND FIRST ARTICLE SPECIFIED REPAIR WELDING
6. AFTER ALL WELDING (INCLUDING REPAIR WELDING) OPERATIONS ARE COMPLETE, STRAIGHTENING (IF REQUIRED) SHALL BE THE MINIMUM NECESSARY TO MEET SPECIFIED DRAWING TOLERANCES. ALL STRAIGHTENING PROCEDURES TO BE FULLY DOCUMENTED, INCLUDING BEFORE AND AFTER CONDITIONS
7. ALL FABRIC... PROCEDURES TO BE DOCUMENTED FOR ENGINEER... REFERENCE.
8. *SURFACE INS*... CRITERIA FOR ALL WELDS TO BE PER NAVSEA 09..-LP-003-8000 (CLASS 3 MINIMUM) BASED ON 100% V... AL AND *GROUP III LIQUID DYE PENETRANT INSPECTION*
9. *100% RADIOGRAPHIC* INSPECTION OF ALL BUTT WELDS TO BE PERFORMED PER MIL-STD 271. ACCEPTANCE CRITERIA TO BE PER NAVSEA 09..-LP-003-9000 (CLASS 3 MINIMUM)

(NOTES CONT'D)

10. ALL INSPECTIONS TO BE FULLY DOCUMENTED INCLUDING PROCEDURES, GENERAL DESCRIPTIONS AND LOCATIONS OF ACCEPTABLE IMPERFECTIONS, AND DETAILED NATURE, SIZES AND LOCATIONS OF ALL IMPERFECTIONS EXCEEDING SPECIFIED ACCEPTANCE STANDARDS.

11 PERMANENTLY IDENTIFY EACH ASSEMBLY IN APPROX. LOCATION SHOWN, USING CHARACTERS 1/4" HIGH MIN. IDENTIFICATION TO CONSIST OF LAST 3 DIGITS OF DRAWING NUMBER FOLLOWED BY ASSY DASH NO., e.g. 015-11.

12 REMOVE FRONT AND BACK FACE WELD BEAD REINFORCEMENTS BY SHAVING FLUSH TO .030 ABOVE MATERIAL SURFACE ON HIGHER SIDE OF JOINT PER *PLANNED 3KSES PRODUCTION PROCEDURES. DO NOT GRIND. DO NOT SHAVE WHEN WELD BEAD REINFORCEMENT IS BELOW THE MATERIAL SURFACE ON ONE SIDE OF THE JOINT. SHAVE BEADS AFTER COMPLETING ALL WELDING, INCLUDING REPAIR WELDING, AND PRIOR TO ANY PEENING.*

...REPAIRS BY GRINDING OUT SEGMENTS OF ...*REQUIRED TO REMOVE DEFECTIVE WELD AND ...QUALIFIED REPAIR WELD PROCEDURES. DOCUMENTED ...RANT INSPECTIONS ARE REQUIRED BEFORE ... WELDING.* USE *GROUP III LIQUID PENETRANT*

...NG WELD REPAIR REQUIREMENTS PER 13, ...ED WELD REPAIRS BY GRINDING OUT ...LD BEAD INDICATED BY ON F/D AND ...QUALIFIED REPAIR WELD PROCEDURES. ...NS SHOWN ON F/D APPLY TO COMPLETED ...AD. SIMULATE ADDITIONAL WELD REPAIRS ... ON F/D IN A SIMILAR MANNER. ...UAL AND DYE PENETRANT INSPECTIONS ...FORE AND AFTER REPAIR WELDING AND ...R WELDING.

PARTS LIST

PART NUMBER: -805, -803, -801, -127, -121, -119, -117, -115, -113, -111, -109, -107, -105, -103, -101, -15, -11, -9, -7, -5, -3, -1

Assembly columns: -127, -121, -119, -117, -115, -113, -111, -109, -107, -105, -103, -101, -15, -11, -9, -7, -5, -3, -1

QUANTITY REQUIRED PER ASSY

Row -801: 2, 2, 2, 2, 2, 2 (in columns -15 to -1)

REVISION STATUS OF SHEETS | REV. | SHEET

DOCUMENT ...

4 | 3 | 2

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		A	INCORPORATED ECR T00 67		

ARP EDGES

E SPECIFIED, ALL FABRICATION, WELDING AND
E PER NAVSEA 0900-LP-060-4010

PER AWS-A-2.0. EXCEPT AS NOTED. ALL WELDING TO BE
PER PROCEDURES QUALIFIED FOR 3KSES
HE SAME JOINT CONFIGURATION.

RS OTHER THAN THOSE SPECIFIED ARE NOT PERMITTED
FIC STRUCTURES ENGINEERING APPROVAL.

UCTURES ENGINEER TO WITNESS FIRST
ING AND FIRST ARTICLE SPECIFIED REPAIR WELDING.

LDING (INCLUDING REPAIR WELDING) OPERATIONS
, STRAIGHTENING (IF REQUIRED) SHALL BE THE
ESSARY TO MEET SPECIFIED DRAWING TOLERANCES.
ING PROCEDURES TO BE FULLY DOCUMENTED,
ORE AND AFTER CONDITIONS.

ON PROCEDURES TO BE DOCUMENTED FOR
REFERENCE.

TION CRITERIA FOR ALL WELDS TO BE PER
00-LP-003-8000 (CLASS 3 MINIMUM) BASED
AL AND GROUP III LIQUID DYE PENETRANT INSPECTION

INSPECTION OF ALL BUTT WELDS TO BE PERFORMED
71. ACCEPTANCE CRITERIA TO BE PER
0-LP-003-9000 (CLASS 3 MINIMUM).

-15	-11	-9	-7	-5	-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
							-805	2/D7	PLATE	5456 H116/H117 AL ALY	.313×12.0×24.0	QQ-A 250/20	
							-803	2/D7	PLATE	5456 H116/H117 AL ALY	.180×12.0×24.0	QQ-A-250/20	
2	2	2	2	2	2	2	-801	2/D7	PLATE	5456 H116/H117 AL ALY	.160×12.0×24.0	QQ-A-250/20	
							-127	3/C6	WELD ASSY				[illegible]
							-121	3/C6	WELD ASSY				
							-119						
							-117						
							-115						
							-113						
							-111						
							-109						[illegible]
							-107						[illegible]
							-105						[illegible]
							-103						[illegible]
							-101	3/C6	WELD ASSY				
-							-15	3/C6	WELD ASSY				[illegible]
	-						-11	3/C6	WELD ASSY				
		-					-9						[illegible]
			-				-7						
				-			-5						
					-		-3						
						-	-1	3/C6	WELD ASSY				

QUANTITY REQUIRED PER ASSY

PARTS LIST

REVISION STATUS OF SHEETS	REV.	A	A
	SHEET	1	2

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3KSES

PLATE WELDMENTS, TRANSVERSE BUTT-STRUCTURAL TEST

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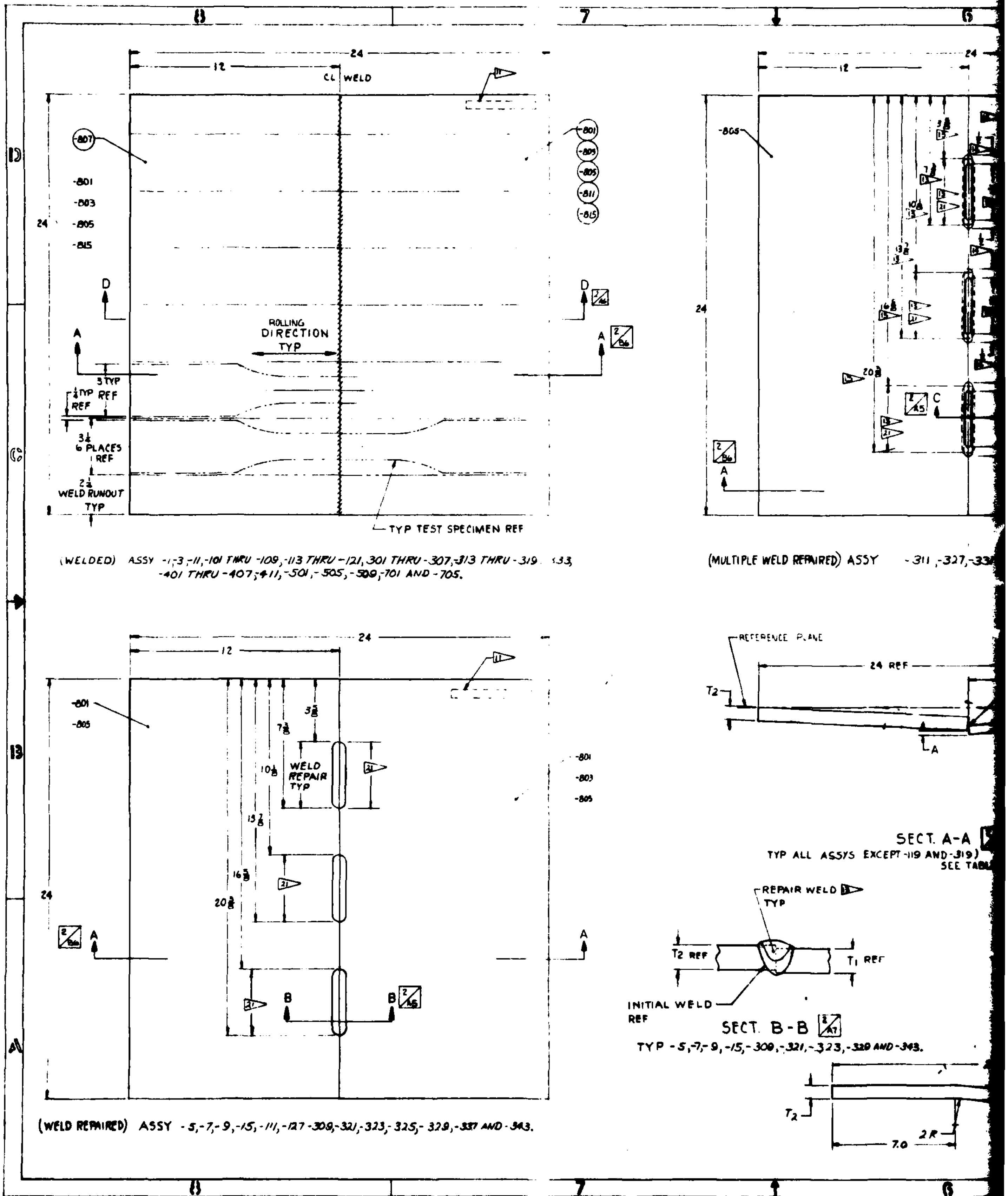
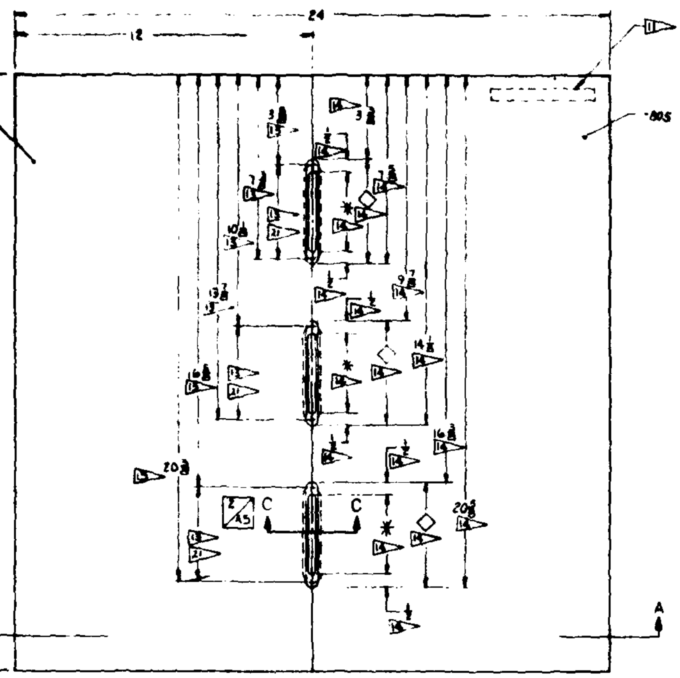
SCALE NONE SHEET 1 OF 2

2

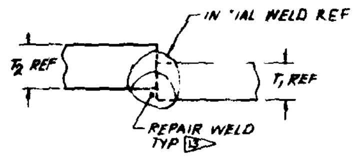


CL WELD
ROLLING DIRECTION TYP
5 TYP
1/4 TYP REF
REF
3 1/4 6 PLACES REF
2 1/4 WELD RUNOUT TYP
TYP TEST SPECIMEN REF
(WELDED) ASSY -1,-3,-11,-101 THRU -109,-113 THRU -121,301 THRU -307,-313 THRU -319, -333, -401 THRU -407,-411,-501,-505,-509,-701 AND -705.
(MULTIPLE WELD REPAIRED) ASSY -311,-327,-33
WELD REPAIR TYP
(WELD REPAIRED) ASSY -5,-7,-9,-15,-111,-127 -309,-321,-323,-325,-329,-337 AND -343.
REFERENCE PLANE
24 REF
SECT. A-A
TYP ALL ASSYS EXCEPT -119 AND -319)
SEE TAB
REPAIR WELD
TYP
T2 REF
T1 REF
INITIAL WELD REF
SECT. B-B
TYP -5,-7,-9,-15,-309,-321,-323,-329 AND -343.

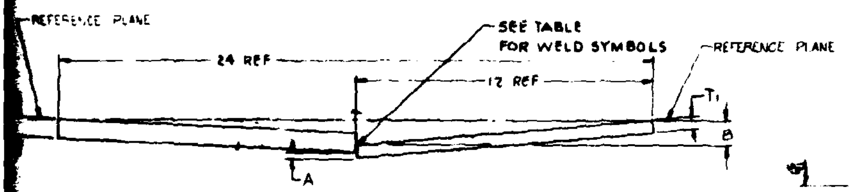
2

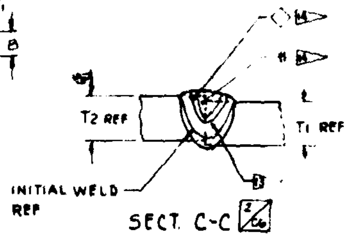


(MULTIPLE WELD REPAIRED) ASSY -311, -327, -331 AND -339



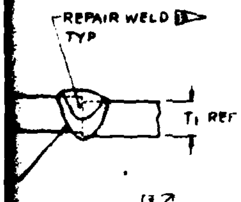
SECT B-B
TYP -111 AND -127 ONLY



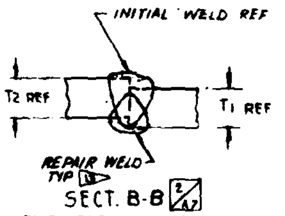


SECT. A-A
TYP ALL ASSYS EXCEPT -119 AND -319)
SEE TABLE

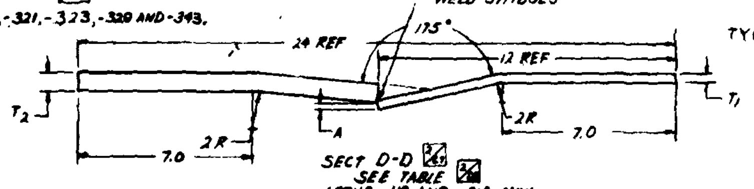
SECT. C-C
TYP -311, -327, -331 AND -339 ONLY



SECT. B-B
-315, -309, -321, -323, -329 AND -343.



SECT. B-B
TYP -325 AND -337 ONLY



SECT D-D
SEE TABLE
ASSYS -119 AND -319 ONLY

(TAB BLOCK CONT'D)

ASSY NO	T_1 REF	T_2 REF	A	B		
-401	.313	.313	0 TO [illegible]	0 ± [illegible]		
-403						
-405						
-407	.313	.313	0 TO [illegible]	0 ± [illegible]		
-411	.313	.313	[illegible] TO [illegible]	0 ± [illegible]		
-501	.375	.500	0 TO [illegible]	0 ± [illegible]		
-505	.375	.500	0 TO [illegible]	0 ± [illegible]		
-509	.375	.500	[illegible] TO [illegible]	0 ± [illegible]		
-701	.750	.750	0 TO [illegible]	0 ± [illegible]		
-705	.750	.750	0 TO [illegible]	0 ± [illegible]		

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FRAME 2 — FRAME 1

3

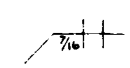
6 | 3 | 2

ASSY NO.	T1 REF	T2 REF	A	B					WELD SYMBOL FIG NO.
(TAB BLOCK CONT'D)									
-401	.313	.313	0 TO 1/16	0 ± 1/4					7
-403									8
-405									7
-407	.313	.313	0 TO 1/16	0 ± 1/4					7
-411	.313	.313	1/16 TO 1/8	0 ± 1/4					10
-501	375	.500	0 TO 1/8	0 ± 1/4					9
-505	.375	.500	0 TO 1/8	0 ± 1/4					9
-509	.375	.500	1/8 TO 1/4	0 ± 1/4					10
-701	.750	.750	0 TO 1/8	0 ± 1/4					14
-705	.750	.750	0 TO 1/8	0 ± 1/4					14

ASSY NO.	T1 REF	T2 REF	A	B				WELD SYMBOL FIG NO.
TAB BLOCK								
-1	.160	.160	0 TO 1/16	0 ± 1/4				1
-3								2
-5								1 21
-7								2 21
-9			0 TO 1/16					1 21
-11	.160	.160	1/16 TO 1/8	0 ± 1/4				6
-15	.160	.160	0 TO 1/16	0 ± 1/4				1 21
-101	.190	.313	0 TO 1/16	0 ± 1/4				4
-103								4
-105								4
-107								4
-109								4
-111			0 TO 1/16					4 21
-113			1/16 TO 1/8					4
-115			1/16 TO 1/8					6
-117			1/16 TO 1/8	0 ± 1/4				5
-119			0 TO 1/16					4
-121	.190	.313	0 TO 1/16	0 ± 1/4				4
-127	.190	.313	0 TO 1/16	0 ± 1/4				4 21
-301	.313	.313	0 TO 1/16	0 ± 1/4				1
-303								2
-305								1
-307								1
-309								1 21
-311								1 21
-313			0 TO 1/16					2
-315			1/16 TO 1/8					6
-317			1/16 TO 1/8	0 ± 1/4				5
-319			0 TO 1/16					2
-321				0 ± 1/4				2 21
-323								2 21
-325								1 21
-327								1 21
-329								1 21
-331			0 TO 1/16					1 21
-333	.313	.313	1/16 TO 1/8	0 ± 1/4				6
-337	.313	.313	0 TO 1/16	0 ± 1/4				2 21
-339	.313	.313	0 TO 1/16	0 ± 1/4				2 21
-343	.313	.313	1/16 TO 1/8	0 ± 1/4				5 21

WELD SYMBOL 21 (CONT'D)

FIG 14



FRAME 1

6 | 3 | 2

4

REV	DESCRIPTION
A	INCORPORATED ECR 00067

WELD SYMBOL FIG NO.
1
2
1
2
1
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1
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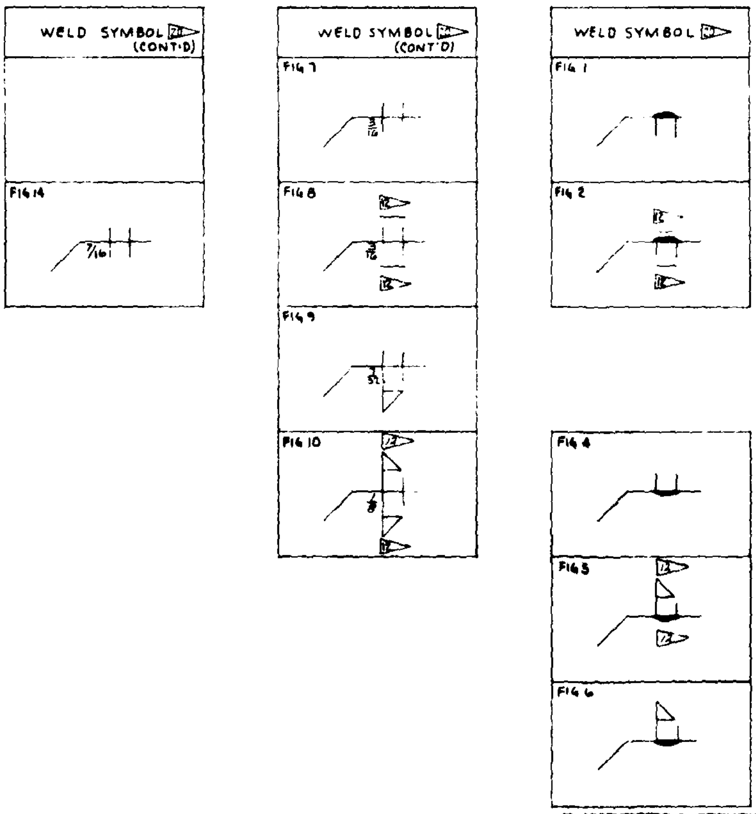
2
5



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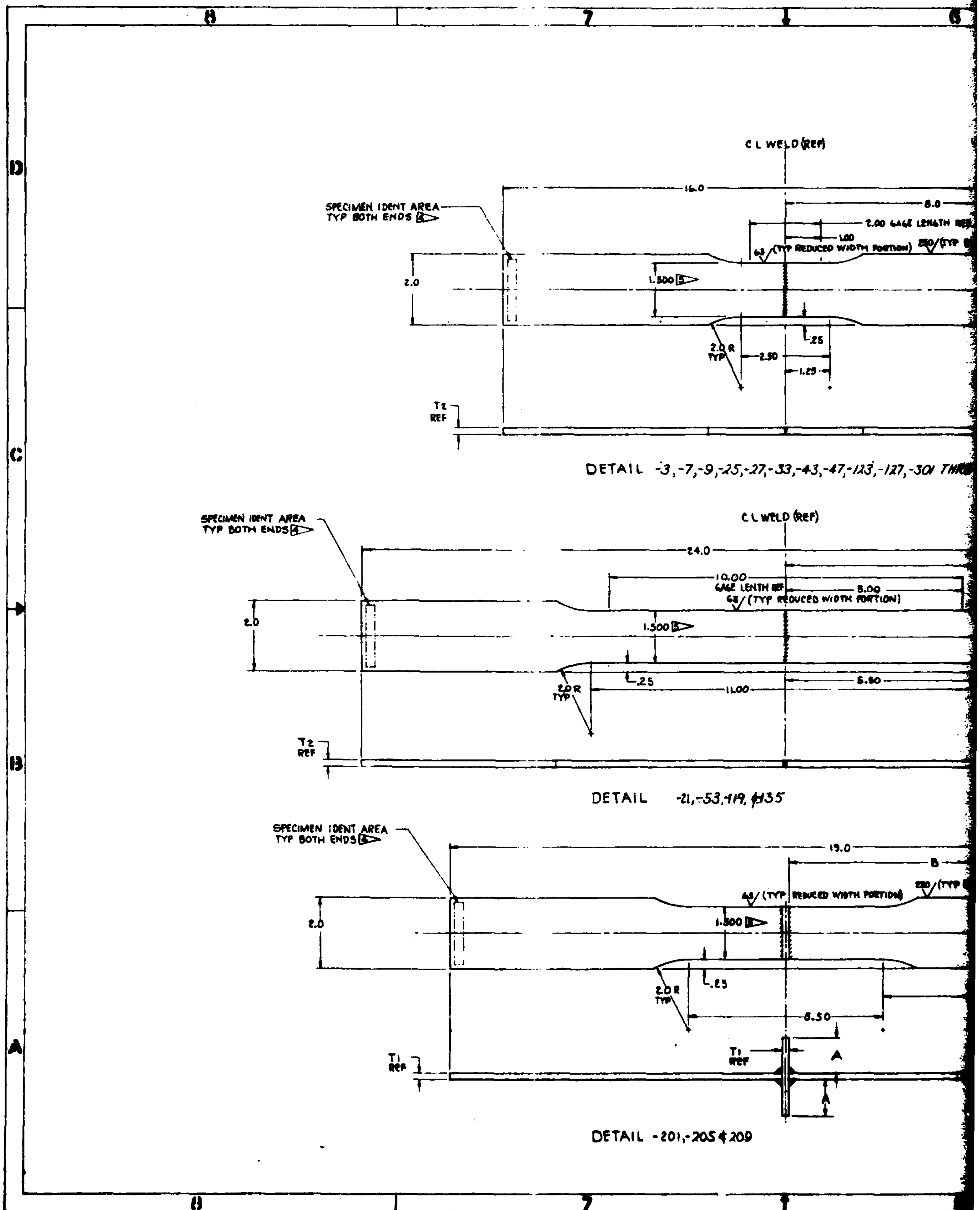
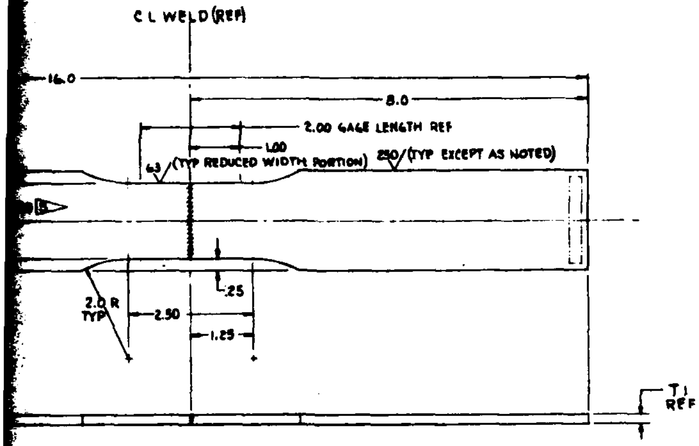
SHEET 2



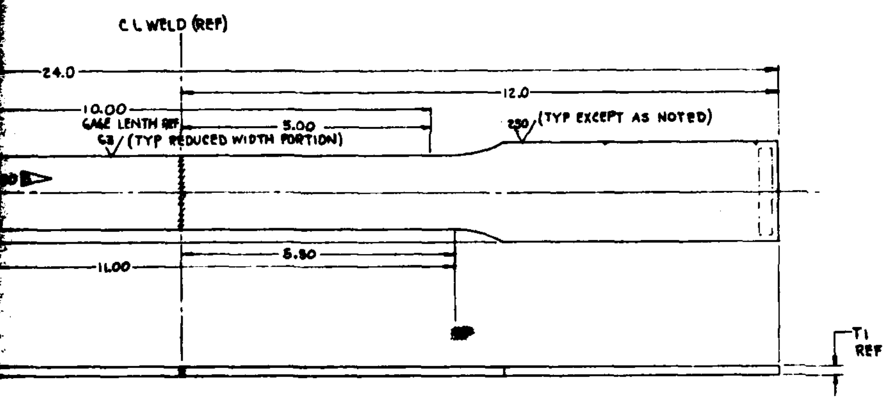
8
7
6
D
C
B
A
C L WELD (REF)
SPECIMEN IDENT AREA
TYP BOTH ENDS 4
16.0
8.0
2.00 GAGE LENGTH REF
1.00
63 (TYP REDUCED WIDTH PORTION)
2.0
1.500 5
.25
2.0 R
TYP
2.50
1.25
T2
REF
DETAIL -3,-7,-9,-25,-27,-33,-43,-47,-123,-127,-301 THRU
C L WELD (REF)
SPECIMEN IDENT AREA
TYP BOTH ENDS 4
24.0
10.00
GAGE LENTH REF
5.00
63 (TYP REDUCED WIDTH PORTION)
2.0
1.500 5
.25
2.0 R
TYP
11.00
5.50
T2
REF
DETAIL -21,-53,-119, & 135
SPECIMEN IDENT AREA
TYP BOTH ENDS 4
19.0
B
63 (TYP REDUCED WIDTH PORTION)
2.0
1.500 5
.25
2.0 R
TYP
5.50
T1
REF
T1
REF
A
A
DETAIL -201,-205 & 209
8
7

2

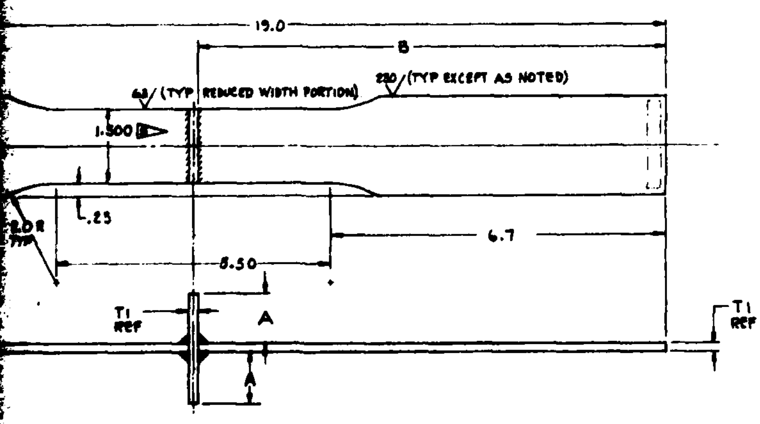
7 | 6 | 5 | 4



3,-7,-9,-25,-27,-33,-43,-47,-123,-127,-301 THRU -307, & -313 THRU -331.



-21,-53,-119, & 135



-201,-205 & 209

DIMENSION TABLE				
ASSY NO	T1 REF	T2 REF	A	B
-3	.190	.313		
-7	.313	.313		
-9	.190	.313		
-21	.313	.313		
-25	.313	.313		
-27	.190	.313		
-33	.313	.313		
-43	.313	.313		
-47	.313	.313		
-53	.313	.313		
-119	.313	.313		
-123	.313	.313		
-127	.375	.500		
-201	.180		.38	9.4
-205	.500		1.0	9.3
-209	.750		1.5	9.1
-301	.190	.190		
-303				
-305				
-307	.190	.190		
-313	.190	.190		
-315				
-317	.190	.190		
-319	.375	.375		
-321	.375	.375		

TT802016 A

FRAME 2 — FRAME 1

7 | 6 | 5 | 4

3

4	3	2

...ON TABLE		
...REF	A	B
.313		
.313		
.313		
.313		
.313		
.313		
.313		
.313		
.313		
.313		
.313		
.313		
.500		
	.38	9.4
	1.0	2.3
	1.3	9.1
.190		
.190		
.190		
.190		
.375		
.375		

4 PERMANENTLY IDENTIFY EACH SPECIMEN IN APPROXIMATE LOCATION SHOWN USING MIN 1/4 IN HIGH CHARACTERS. IDENTIFICATION TO CONSIST OF LAST 3 DIGITS OF DRAWING NO., SPECIMEN DASH NUMBER, & REPLICATE NO. IN THAT ORDER, i.e. 016-27-2.

5 THE ENDS OF THE 1.500 WIDTH STRAIGHT PORTION SHALL NOT DIFFER IN WIDTH BY MORE THAN .004. THE WIDTH AT EITHER END OF THIS STRAIGHT PORTION SHALL NOT BE MORE THAN .015 GREATER THAN THE WIDTH AT THE CENTER.

NOTES:

1. ABBREVIATIONS PER MIL-STD-12.
2. UNTRIMMED PANEL WELDMENT ... STRUCTURES ENGINEERING. CU... TRIM TO SIZES SHOWN ON F/D. L... WELDMENT TO BE COORDINATED ... STRUCTURES ENGINEER.
3. BREAK SHARP EDGES. DO NOT FINI... FROM ANY SPECIMEN FLAT SUR...

DEMENSION TABLE (CONTINUED)		
ASSY NO.	T1 REF	T2 REF
-323	.375	.375
-325		
-327		
-329		
-331	.375	.375

PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
-331	7/C	SPECIMEN, BUTT WPERF	M/F TT802021 -113	2		
-329			-111			
-327			-109			
-325			-107			
-323			-105			
-321			-103			
-319			-101			
-317			-17			
-316			-15			
-315	7/C	SPECIMEN, BUTT WPERF	M/F TT802021-13	3		
-307	7/B	SPECIMEN, BUTT WPERF	M/F TT802021 -7	2		
-305			-5			
-303			-3			
-301	7/B	SPECIMEN, BUTT WPERF	M/F TT802021-1	2		
-209	7/A	SPECIMEN, [illegible] FILLET	M/F TT802017 -9	2		
-205	7/A	SPECIMEN, [illegible] FILLET	M/F TT802017 -5	2		
-201	7/A	SPECIMEN, [illegible] FILLET	M/F TT802017-1	2		

PARTS LIST

-135

-127

-123

-119

PART NUMBER

4	3	2

4

A	INCORPORATED ECHT00067			

...OXIMATE
...ACTERS.
...OF DRAWING NO.
...OR 06-27-2.
...T PORTION
...AN .004
...IGHT PORTION
...R THAN

NOTES:

1. ABBREVIATIONS PER MIL-STD-12.
2. UNTRIMMED PANEL WELDMENT TO BE SUPPLIED BY STRUCTURES ENGINEERING. CUT SPECIMEN BLANKS AND TRIM TO SIZES SHOWN ON F/D. LAYOUT OF SPECIMENS ON PANEL WELDMENT TO BE COORDINATED WITH COGNIZANT STRUCTURES ENGINEER.
3. BREAK SHARP EDGES. DO NOT FINISH OR REMOVE IMPERFECTIONS FROM ANY SPECIMEN FLAT SURFACES.

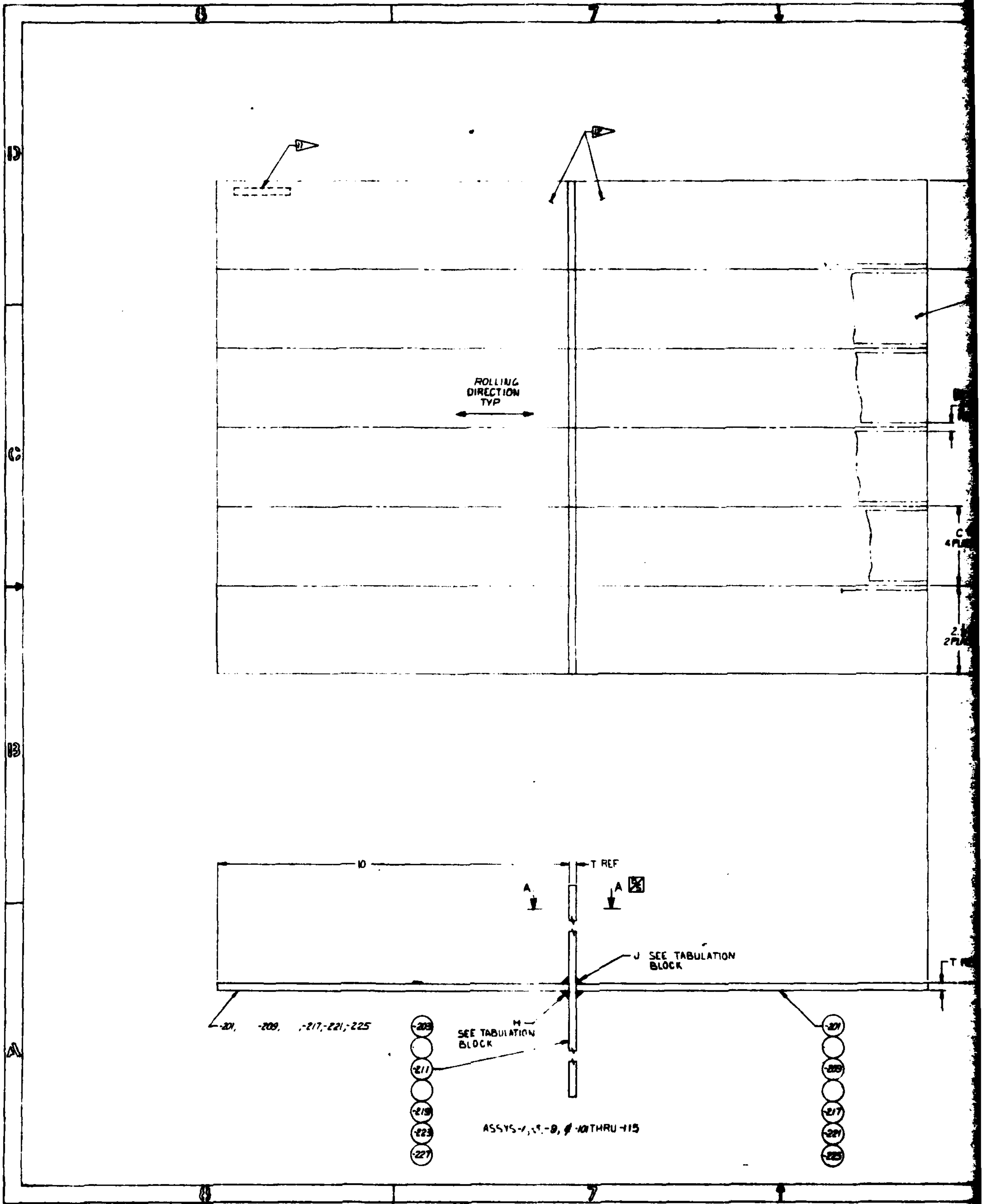
PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
-135	7/B	SPECIMEN, 2 SIDE BUTT	M/F TT802015 -403	2		
-127	7/C	SPECIMEN, 2 SIDE BUTT	M/F TT802015 -309	2		
-123	7/C	SPECIMEN, 2 SIDE BUTT	M/F TT802015 -411	2		
-119	7/B	SPECIMEN, 2 SIDE BUTT	M/F TT802015 -401	2		
-53	7/B	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -303	2		
-47	7/C	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -343	2		
-43	7/C	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -3[illegible]	2		
-33	7/C	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -319	2		
-27	7/C	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -117	2		
-25	7/C	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -317	2		
-21	7/B	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -301	2		
-9	7/C	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -115	2		
-7	7/C	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -315	2		
-3	7/C	SPECIMEN, 1 SIDE BUTT	M/F TT802015 -101	2		

...RIAL | PROCESS

PARTS LIST

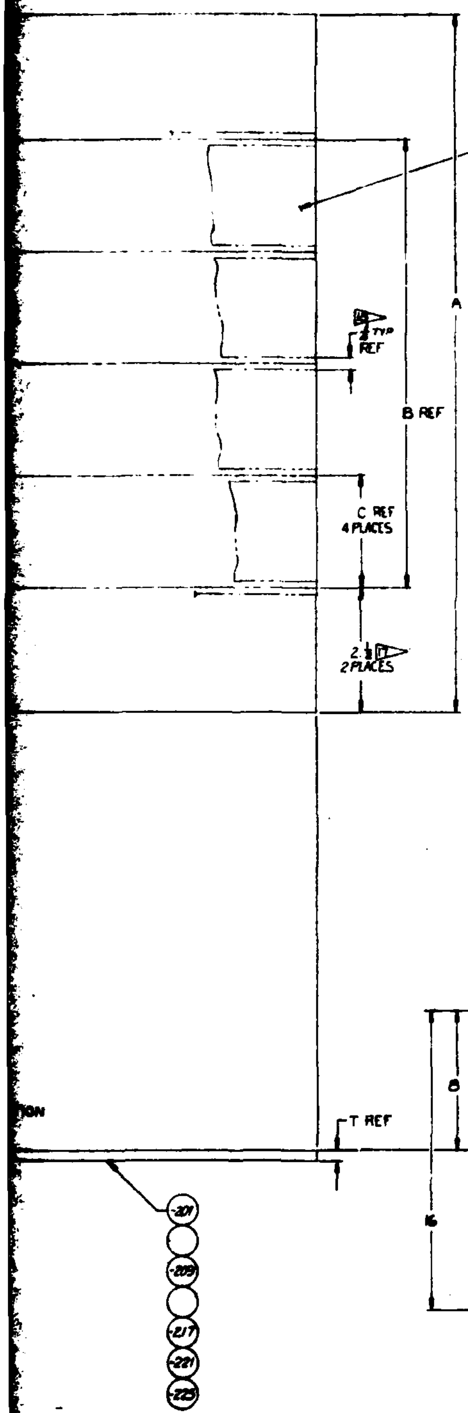
TEST SPECIMENS - WELDED PLATE, STATIC TEST

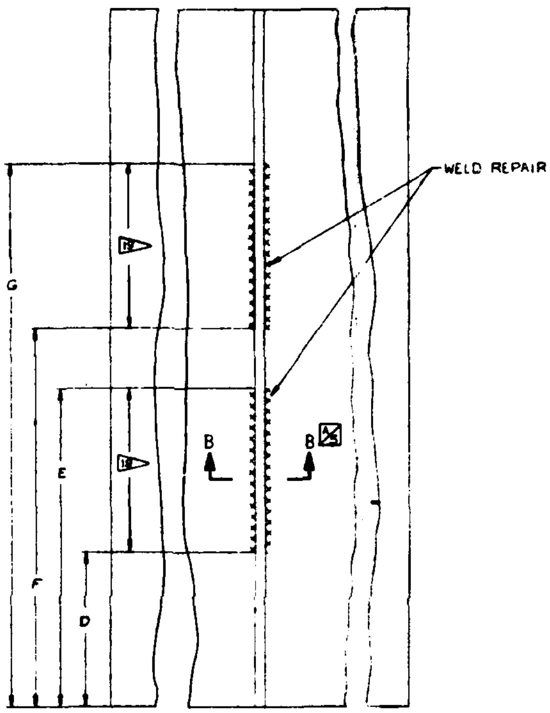
TT802016



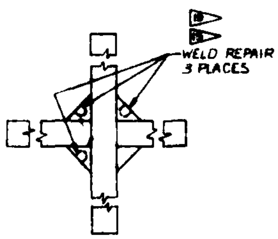
ROLLING DIRECTION TYP
10
T REF
A
A
J SEE TABULATION BLOCK
H
SEE TABULATION BLOCK
-201, -209, ,-217,-221,-225
-203
-211
-219
-223
-227
-201
-209
-217
-221
-225
ASSYS -1,-5,-9, & -101 THRU -115

2 1

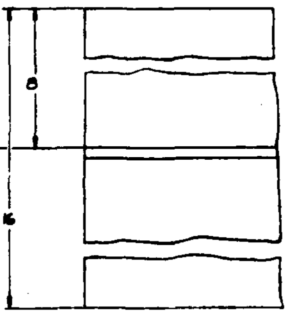




SECTION A-A
ASSYS -109 & -111 ONLY
SAME AS -1, -5, -9, -101 THRU -107, -113 & -115
EXCEPT AS NOTED



SECTION B-B
ASSYS -109 & -111 ONLY



ASSY NO	T REF	A	B REF	C REF
-1	.180	14	9	2 1/4
-5	.500	14	9	2 1/4
-9	.750	14	9	2 1/4
-101	.160	18	13	3 1/2
-103	.160			
-105	.281			
-107	.281			
-109	.281			
-111	.281			
-113	.160			
-115	.281	18	13	3 1/2

TT802017 A

FRAME 2 — FRAME 1

3 1

4 | 3 | 2

TABULATION BLOCK										
ASSY NO	T REF	A	B REF	C REF	D	E	F	G	H	J
-1	.180	14	9	2 1/4	—	—	—	—		
-5	.600	14	9	2 1/4	—	—	—	—		
-9	.750	14	9	2 1/4	—	—	—	—		
-101	.160	18	13	3 1/4	—	—	—	—	3/16	3/16
-103	.160				—	—	—	—	3/16	3/16
-105	.281				—	—	—	—	1/4	1/4
-107	.281				—	—	—	—	1/4	1/4
-109	.281				4 1/8	7 3/8	10 5/8	13 7/8	1/4	1/4
-111	.281				4 1/8	7 3/8	10 5/8	13 7/8	1/4	1/4
-113	.160				—	—	—	—	3/16 3/32 3/32 3/16	3/16 3/32 3/32 3/16
-115	.281	18	13	3 1/4	—	—	—	—	1/4 5/32 5/32 1/4	1/4 5/32 5/32 1/4

11. PERMANENTLY IDENTIFY EACH ASSEMBLY IN APPROXIMATE LOCATION SHOWN USING 1/4 MIN HIGH CHARACTERS. IDENTIFICATION TO CONSIST OF LAST 3 DIGITS OF DRAWING NUMBER FOLLOWED BY ASSEMBLY DASH NUMBER, i.e. 017-101

12. PANEL SURFACE FLATNESS SHALL NOT DEVIATE MORE THAN .250 TIR FROM A FLAT PLANE ESTABLISHED BY HEIGHT BLOCKS LOCATED 1 IN. FROM THE EDGES AT ALL 4 CORNERS OF THE PANEL WELDMENT WITH HAND PRESSURE APPLIED AT ANY CORNER NECESSARY TO PRODUCE CONTACT.

13. AS WELDED BEAD CONTOUR TO BE FLAT OR CONCAVE.

14. AS WELDED BEAD CONTOUR TO BE CONVEX WITH NO REENTRANT ANGLES.

15. MAKE WELD REPAIRS BY GRINDING OUT SEGMENTS OF WELD BEAD AS REQUIRED TO REMOVE DEFECTIVE WELD & REWELDING PER QUALIFIED REPAIR WELD PROCEDURES. DOCUMENTED VISUAL & PENETRANT INSPECTIONS ARE REQUIRED BEFORE & AFTER REPAIR WELDING.

16. PEEN SURFACES OF WELD BEADS OVER FULL LENGTH & SUFFICIENT WIDTH TO COVER HEAT AFFECTED ZONES ON BOTH SIDES. PEENING INTENSITY TO BE .004-.008 ALMEN 'A' STRIP ARC HEIGHT. METHOD OF PEENING (ROTARY FLAPPER OR SHOT) TO BE SPECIFIED BY STRUCTURES ENGINEERING. PEENING TO BE PERFORMED AFTER ALL WELDING, REPAIR WELDING, & STRAIGHTENING OPERATIONS HAVE BEEN COMPLETED & INSPECTED

17. WELD RUNOUT ALLOWANCE

18. CUTTING ALLOWANCE

19. PRIOR TO WELDING, LIGHTLY CONTAMINATE WELD REPAIR ZONES INDICATED WITH KEROSENE TO CREATE WELD DEFECTS. COORDINATE WITH COGNIZANT ENGINEER.

NOTES:

1. BREAK AL
2. UNLESS
TO BE PE
3. WELD SY
4. ALL WELD
3KSES F
5. WELD RE
SPECIFIC
6. COGNIZANT
WELDING
7. AFTER ALL
COMPLETE
TO MEET
PROCEDUR
8. ALL FABR
REFEREN
9. SURFACE
NAVSEA O
& GROUP
10. ALL INSPEC
DESCRIPT
SIZES & L
STANDARD

1		1	1	1	1																227	A7
2		2	2	2	2																-225	
	1					1	1														-223	
	2					2	2														-221	
																1					-219	
																2					-217	A7
																		1			-211	A7
																		2			-209	A7
																				1	-203	A7
																				2	-201	A7
-																					-115	A7
																					-113	
																					-111	
																					-109	
				-																	-107	
					-																-105	
						-															-103	
							-														-101	A7
																-					-9	A7
																		-			-5	A7
																				-	-1	A7
-115	-113	-111	-109	-107	-105	-103	-101									-9		-5		-1	PART NUMBER	ZONE
QUANTITY																						

DOCUMENT RELEASE

4 | 3 | 2

1

4

2

	A	INCORPORATED ECR T0006?	

D

IN APPROXIMATE LOCATION
S. IDENTIFICATION TO
NUMBER FOLLOWED BY

MORE THAN .250 TIR FROM A FLAT
S LOCATED 1 IN. FROM THE EDGES
ENT WITH HAND PRESSURE
PRODUCE CONTACT.
FLAT OR CONCAVE.
CONVEX WITH NO REENTRANT ANGLES.
MENTS OF WELD BEAD AS REQUIRED
NG PER QUALIFIED REPAIR
UAL & PENETRANT
& AFTER REPAIR WELDING.
FULL LENGTH & SUFFICIENT
ON BOTH SIDES. PEENING
RIP ARC HEIGHT, METHOD
T) TO BE SPECIFIED BY
TO BE PERFORMED AFTER
RAIGHTENING OPERATIONS
ED.

MINATE WELD REPAIR ZONES
CREATE WELD DEFECTS.
NGINEER.

NOTES:

1. BREAK ALL SHARP EDGES
2. UNLESS OTHERWISE SPECIFIED, FABRICATION, WELDING & INSPECTION TO BE PER NAVSEA 0900-LP-060-4010
3. WELD SYMBOLS PER AWS-A-2.0
4. ALL WELDING MUST BE PER PROCEDURES QUALIFIED FOR 3KSES PRODUCTION UNLESS OTHERWISE NOTED.
5. WELD REPAIRS OTHER THAN THOSE SPECIFIED ARE NOT PERMITTED WITHOUT SPECIFIC STRUCTURES ENGINEERING APPROVAL
6. COGNIZANT STRUCTURES ENGINEER TO WITNESS FIRST ARTICLE WELDING & FIRST ARTICLE SPECIFIED REPAIR WELDING
7. AFTER ALL WELDING INCLUDING REPAIR WELDING OPERATIONS ARE COMPLETED, STRAIGHTENING (IF REQ'D) SHALL BE THE MINIMUM NECESSARY TO MEET SPECIFIED DRAWING TOLERANCES. ALL STRAIGHTENING PROCEDURES TO BE FULLY DOCUMENTED INCLUDING BEFORE & AFTER CONDITIONS
8. ALL FABRICATION PROCEDURES TO BE DOCUMENTED FOR ENGINEERING REFERENCE.
9. SURFACE INSPECTION CRITERIA FOR ALL WELDS TO BE PER NAVSEA 0900-LP-003-8000 (CLASS 3 MINIMUM) BASED ON 100% VISUAL & GROUP III LIQUID PENETRANT INSPECTION.
10. ALL INSPECTIONS TO BE FULLY DOCUMENTED INCLUDING PROCEDURES, GENERAL DESCRIPTIONS & LOCATIONS OF ACCEPTABLE IMPERFECTIONS & DETAILED NATURE, SIZES & LOCATIONS OF ALL IMPERFECTIONS EXCEEDING SPECIFIED ACCEPTANCE STANDARDS.

NOTES CONTINUED NEXT COLUMN

C

			-9		-5		-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
								-227	A7	PLATE	AL ALY 5456 H116/H117	.281 X 16 X 18	QQ-A-250/20	
								-225				.281 X 10 X 18		
								-223				.160 X 16 X 18		
								-221				.160 X 10 X 18		
			1					-219				.750 X 14 X 16		
			2					-217	A7	PLATE	AL ALY 5456 H116/H117	.750 X 10 X 14	QQ-A-250/20	
					1			-211	A7	PLATE	AL ALY 5456 H116/H117	.500 X 14 X 16	QQ-A-250/20	
					2			-209	A7	PLATE	AL ALY 5456 H116/H117	.500 X 10 X 14	QQ-A-250/20	
							1	-203	A7	PLATE	AL ALY 5456 H116/H117	.180 X 14 X 16	QQ-A-250/20	
							2	-201	A7	PLATE	AL ALY 5456 H116/H117	.180 X 10 X 14	QQ-A-250/20	
								-115	A7	WELD ASSY				
								-113						
								-111						10
								-109						
								-107						
								-105						
								-103						
								-101	A7	WELD ASSY				
			-					-9	A7	WELD ASSY				
					-			-5	A7	WELD ASSY				
							-	-1	A7	WELD ASSY				

PARTS LIST

B

A

DOCUMENT RELEASE
M. J. Frein 9-29-77

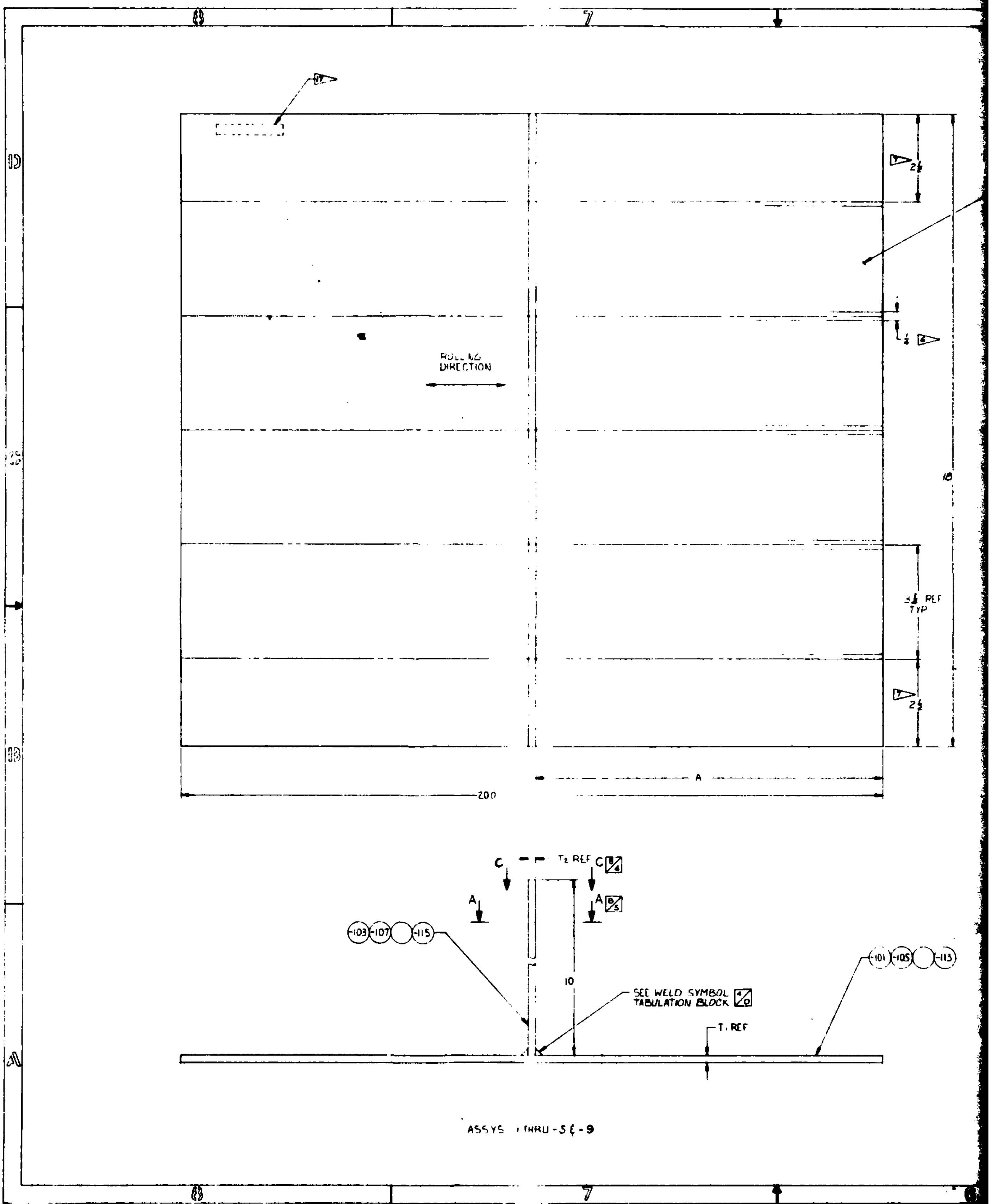
PLATE WELDMENTS, TRANSVERSE CRUCIFORM STRUCTURAL TEST

J

TT802017

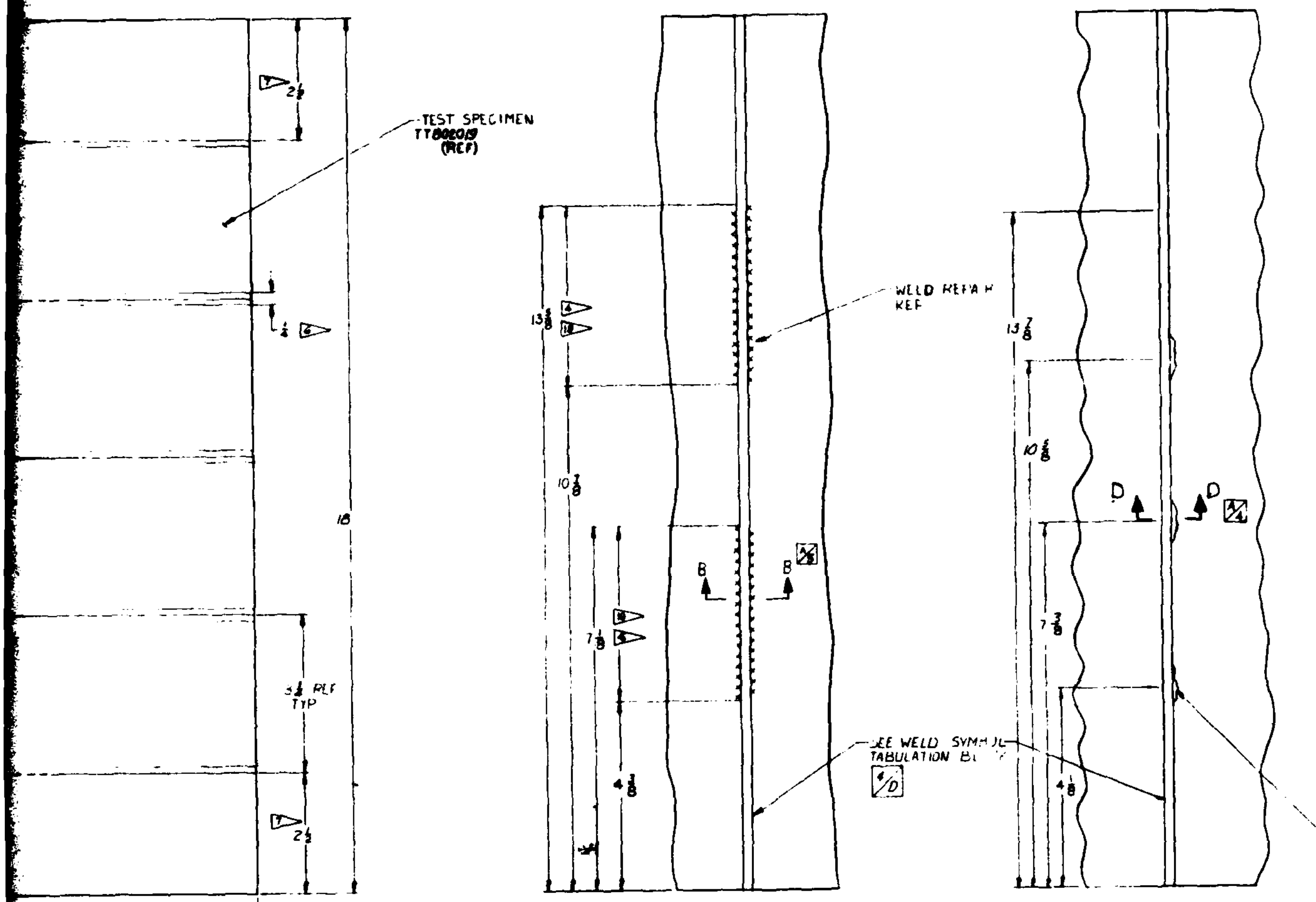
A

2



ROLLING DIRECTION
18
3½ REF TYP
A
200
T2 REF
C
A
10
SEE WELD SYMBOL TABULATION BLOCK
T1 REF
-103 -107 -115
-101 -105 -113
ASSYS 1 THRU -5 & -9

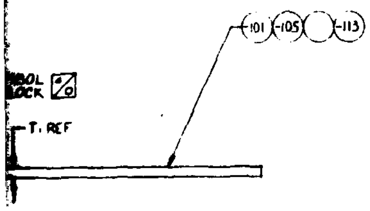
2-1

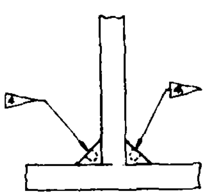


TABULATION BLOCK			
ASSY NO	T_1 REF	T_2 REF	A
-1	.160	.160	9[illegible]
-3	.313	.313	$9\frac{7}{8}$
-5	.313	.313	$9\frac{7}{8}$
-9	.200	.375	9[illegible]
-11	.313	.313	$9\frac{7}{8}$
-13	.313	.313	$9\frac{7}{8}$
-23	.313	.313	$9\frac{7}{8}$
-25	.313	.313	$9\frac{7}{8}$

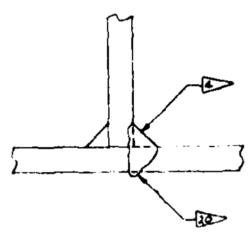
SECTION A-A
ASSYS -11 & -13 ONLY
(SAME AS -1 THRU -5 & -9 EXCEPT AS NOTED)

SECTION C-C
ASSYS -23 & -25 ONLY
(SAME AS -1, -3, -5 & -9 EXCEPT AS NOTED)





SECTION B-B
TYP 2 PLACES



SECTION D-D
TYP 4 PLACES

TT802018 A

TABULATION BLOCK				
ASSY NO	T_1 REF	T_2 REF	A	WELD SYMBOL
-1	.160	.160	9 13/16	3/16 ; 3
-3	.313	.313	9 7/8	5/16 ; 2
-5	.313	.313	9 7/8	5/16 ; 3
-9	.200	.375	9 13/16	3/16 ; 2
-11	.313	.313	9 7/8	5/16 ; 3, 19
-13	.313	.313	9 7/8	5/16 ; 3, 19
-23	.313	.313	9 7/8	5/16 ; 3, 20
-25	.313	.313	9 7/8	5/16 ; 3, 20

20 TYP 4 PLACES

D 24

C-C 7
-25 ONLY
-3 & -9 EXCEPT AS NOTED)

NOTES:

1 PANEL SURFACE FLATNESS [illegible] A FLAT PLANE ESTABLISHED [illegible] THE EDGES AT ALL 4 CORNER[illegible] AT ANY CORNER NECESSA[illegible]

2 AS-WELDED BEAD CONTOU[illegible]

3 AS WELDED BEAD CONTO[illegible]

4 MAKE WELD REPAIRS BY G[illegible] TO REMOVE DEFECTIVE W[illegible] PROCEDURES. DOCUMENT[illegible] REQUIRED BEFORE & AFTE[illegible] LIQUID PENETRANT ONLY[illegible]

5 PEEN SURFACES OF WEL[illegible] WIDTH TO COVER HEAT AFFEC[illegible] AREAS [illegible] TO BE .004-.008 ALM[illegible] FLAPPER OR SHOT) TO BE S[illegible]

6 SPECIMEN CUTTING ALLOWANC[illegible]

7 WELD RUNOUT ALLOWANCE

NOTES CONTINUED

8. BREAK ALL SHARP EDGES

9. UNLESS OTHERWISE SPECIFIED FAB[illegible]ATION WELDING & INSPECTION TO BE PER NAVSEA [illegible] LP 060-4010.

10. WELD SYMBOLS PER AWS-A-2.0

11. EXCEPT AS NOTED, ALL WELDING MUST [illegible] PER PROCEDURES QUALIFIED FOR 3KSES PRODUCTION WELDING.

12. WELD REPAIRS OTHER THAN THOSE SPECIFIED ARE NOT PERMITTED WITHOUT SPECIFIC STRUCTURES ENGINEERING APPROVAL

13. COGNIZANT STRUCTURES ENGINEER [illegible] WITNESS FIRST ARTICLE WELDING & FIRST ARTICLE SPECIFIE[illegible] REPAIR WELDING.

14. STRAIGHTENING, IF REQD AFTER ALL WE[illegible] & REPAIR WELDING IS COMPLETED, SHALL BE MINIMUM NEC[illegible]ARY TO MEET SPECIFIED DRAWING TOLERANCES. ALL STRAIGHTENING PROCEDURES TO BE FULLY DOCUMENTED INCLUDING BEFORE & AFTER CONDITIONS.

15. SURFACE INSPECTION CRITERIA FOR [illegible] TO BE PER NAVSEA 0900-LP-003-8000 (CLASS [illegible] MM) BASED ON 100% VISUAL & GROUP III PENETRANT INSPECTION.

16. ALL INSPECTIONS TO BE FULLY [illegible]MENTED INCLUDING PROCEDURES, GENERAL DESCR[illegible] & LOCATIONS OF ACCEPTABLE IMPERFECTIONS & [illegible]TAILED NATURE, SIZES & LOCATIONS OF ALL IMPERFECTIONS EXCEEDING SPECIFIED ACCEPTANCE STANDARDS.

17. PERMANENTLY IDENTIFY EACH ASSEMBLY IN APPROX LOCATION SHOWN USING 1/4 MIN HIGH CHARACTER[illegible] IDENTIFICATION TO CONSIST OF LAST 3 DIGITS OF DRAWING NUMBER FOLLOWED BY ASSEMBLY DASH NUMBER i.e. 018-13

18. ALL FABRICATION PROCEDURE[illegible] TO BE DOCUMENTED FOR ENGINEERING REFERENCE.

19. PRIOR TO WELDING, LIGHTLY CONTAMINATE WELD REPAIR ZONES INDICATED WITH KEROSENE TO CREATE WELD DEFECTS. COORDINATE WITH COGNIZANT ENGINEER.

20. DURING FILLET WELDING, BURN THROUGH -105 PLATE APPROX. 3/4 IN LONG AT FOUR LOCATIONS PER ASSEMBLY AS INDICATED.

-25	-23	-13	-11	-9	-5	-3	-1	PART NUMBER
				1				-115
				1				-113
1	1	1	1		1	1		-107
1	1	1	1		1	1		-105
							1	-103
							1	-101
-								TT802018 -25
	-							TT802018 -23
		-						TT802018 -13
			-					-11
				-				TT802018 -9
					-			TT802018 -5
						-		-3
							-	TT802018 -1

QUANTITY | PART NUMBER | ZONE

DOCUMENT RELEASE

LTR	DESCRIPTION	DATE	APPROVED
A	INCORPORATED ECR T00067		

NOTES:

1 PANEL SURFACE FLATNESS SHALL NOT DEVIATE MORE THAN .250 TIR FROM A FLAT PLANE ESTABLISHED BY HEIGHT BLOCKS LOCATED 1 IN FROM THE EDGES AT ALL 4 CORNERS OF THE PANEL WELDMENT WITH HAND PRESSURE APPLIED AT ANY CORNER NECESSARY TO PRODUCE CONTACT.

2 AS-WELDED BEAD CONTOUR TO BE FLAT OR CONCAVE.

3 AS WELDED BEAD CONTOUR TO BE CONVEX WITH NO REENTRANT ANGLES.

4 MAKE WELD REPAIRS BY GRINDING OUT SEGMENTS OF WELD BEAD AS REQUIRED TO REMOVE DEFECTIVE WELD & REWELDING PER QUALIFIED REPAIR WELD PROCEDURES. DOCUMENTED VISUAL & PENETRANT INSPECTIONS ARE REQUIRED BEFORE & AFTER REPAIR WELDING. USE GROUP III LIQUID PENETRANT ONLY.

5 PEEN SURFACES OF WELD BEADS OVER FULL LENGTH & SUFFICIENT WIDTH TO COVER HEAT AFFECTED ZONE ON BOTH SIDES. PEENING INTENSITY TO BE 004-008 ALMEN "A" STRIP ARC HEIGHT. METHOD OF PEENING (ROTARY FLAPPER OR SHOT) TO BE SPECIFIED BY STRUCTURES ENGINEER NO.

6 SPECIMEN CUTTING ALLOWANCE

7 WELD RUNOUT ALLOWANCE

NOTES CONTINUED NEXT COLUMN

-11	-9		-5	-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
	1					-115		PLATE	AL ALY 5456 H116/H117	.375 X 10 X 18	QQ-A-250/20	
	1					-113		PLATE	AL ALY 5456 H116/H117	.200 X 18 X 20	QQ-A-250/20	
1			1	1		-107		PLATE	AL ALY 5456 H116/H117	.313 X 10 X 18	QQ-A-250/20	
1			1	1		-105				.313 X 18 X 20		
					1	-103				.160 X 10 X 18		
					1	-101		PLATE	AL ALY 5456 H116/H117	.160 X 18 X 20	QQ-A-250/20	
						TT802018 -25		WELD ASSY				5
						TT802018 -23		WELD ASSY				
						TT802018 -13		WELD ASSY				5
–						-11						
	–					TT802018 -9		WELD ASSY				
			–			TT802018 -5		WELD ASSY				
				–		-3						
					–	TT802018 -1		WELD ASSY				

QUANTITY

PARTS LIST

CONTRACT NO. N00024-77-C-2032

DRAWN R. BEACH

ROHR MARINE, INC.

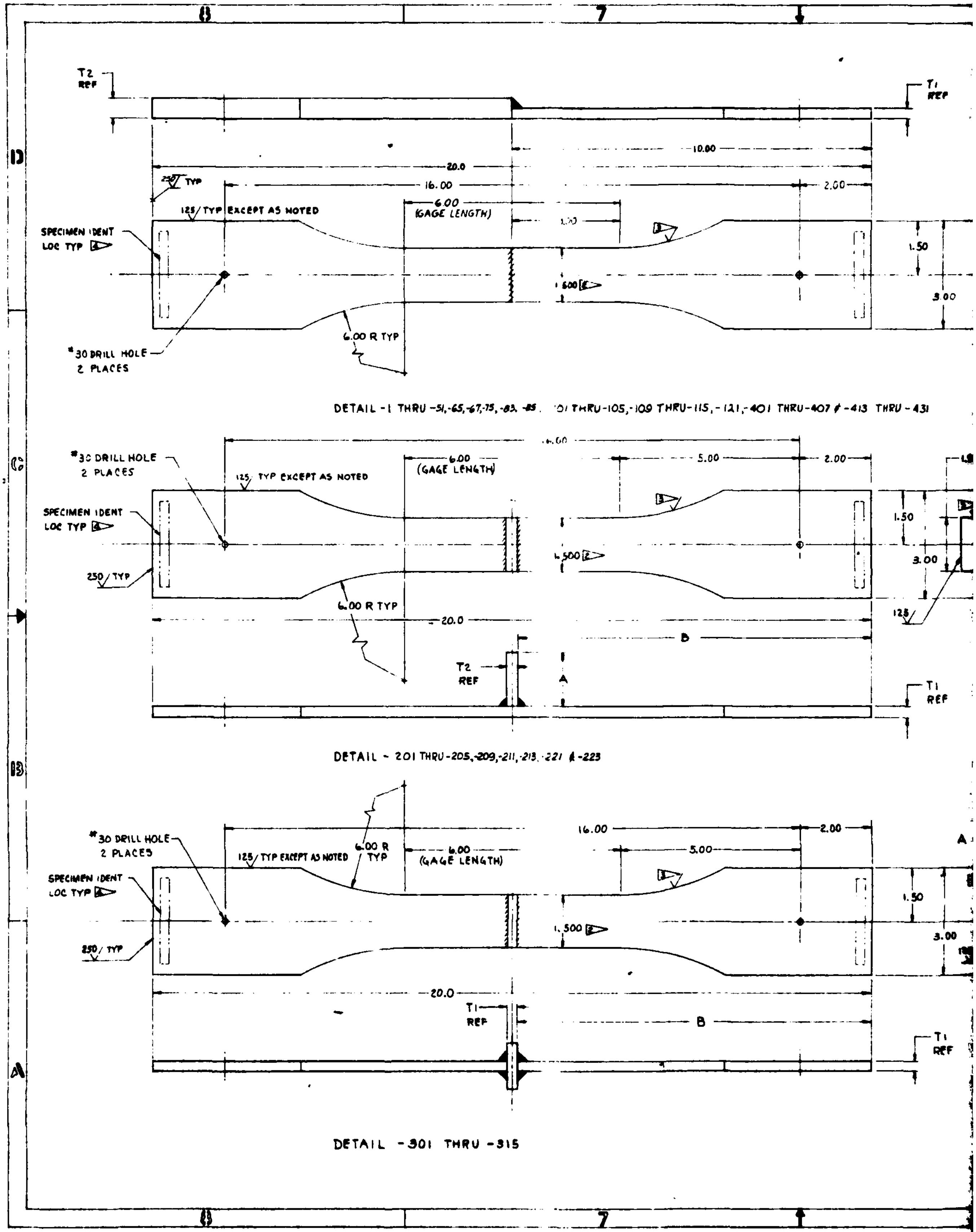
3KSES SURFACE EFFECT SHIP

PLATE WELDMENTS - TRANSVERSE TEE, STRUCTURAL TEST

SIZE J | DWG NO TT802018 | REV A

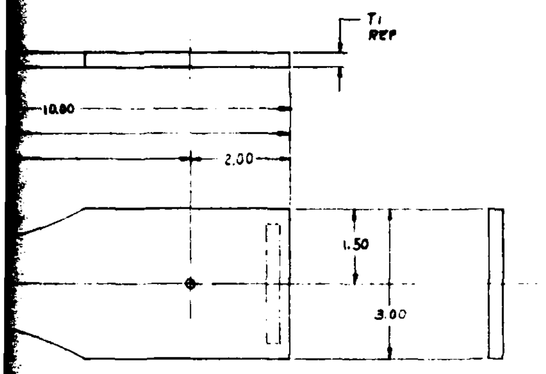
SCALE NONE | SHEET 1 OF 1

DOCUMENT RELEASE

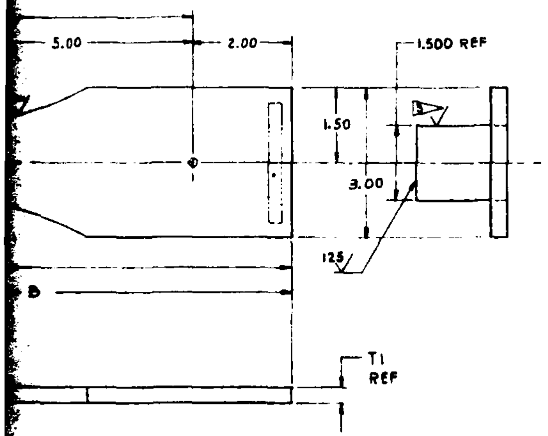


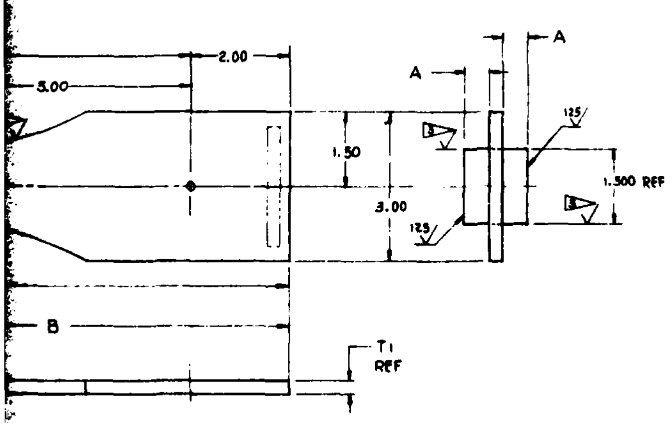
T2 REF
T1 REF
10.00
20.0
16.00
2.00
250 TYP
125/ TYP EXCEPT AS NOTED
6.00 (GAGE LENGTH)
SPECIMEN IDENT LOC TYP
1.50
3.00
.600
6.00 R TYP
#30 DRILL HOLE 2 PLACES
DETAIL -1 THRU -51, -65, -67, -75, -83, -85, -101 THRU -105, -109 THRU -115, -121, -401 THRU -407 & -413 THRU -431
5.00
.500
125
B
A
DETAIL - 201 THRU -205, -209, -211, -213, -221 & -223
6.00 R TYP
DETAIL -301 THRU -315

2'



-115, -121, -401 THRU -407 & -413 THRU -431





ASSY NO.	DIMENSION T1 REF	T2 REF	A	B
-1	.160	.160		
-3	.313	.313		
-5	.190	.313		
-7	.160	.160		
-9	.313	.313		
-11	.313	.313		
-13	.190	.313		
-15	.190	.313		
-17	.313	.313		
-19	.190	.313		
-21	.190	.313		
-23	.160	.160		
-25	.190	.313		
-27	.160	.160		
-29	.313	.313		
-31	.190	.313		
-33	.160	.160		
-35	.313	.313		
-37	.313	.313		
-39	.313	.313		
-41	.190	.313		
-43	.313	.313		
-45	.190	.313		
-47	.160	.160		
-49	.313	.313		
-51	.313	.313		
-65	.160	.160	—	—
-67	.313	.313	—	—
-75	.313	.313	—	—
-83	.313	.313	—	—
-85	.313	.313	—	—
-101	.313	.313		
-103	.750	.750		
-105	.375	.500		
-109	.313	.313		
-111	.750	.750		
-113	.375	.500		
-115	.313	.313		
-121	.313	.313	—	—
-201	.160	.160	.4	9.9
-203	.313	.313	.6	9.8
-205	.313	.313	.6	9.8
-209	.200	.375	.6	9.8
-211	.313	.313	.6	9.8
-213	.313	.313	.6	9.8
-221	.313	.313	.6	9.8
-223	.313	.313	.6	9.8
-301	.160	—	.4	9.9
-303	.160	—	.4	
-305	.281	—	.5	
-307	.281	—	.5	
-309	.281	—	.5	
-311	.281	—	.5	
-313	.160	—	.4	
-315	.281	—	.5	9.9
-401	.190	.190		
-403				
-405				
-407	.190	.190		
-413	.190	.190	—	—
-415	.190	.190	—	—

ASSY NO	DIMENSI[ON] T1 REF	T2 REF
-417	.190	.190
-419	.375	.375
-421		
-423		
-425		
-427		
-429		
-431	.375	.375

T802019 A

SH 1

FRAME 2 — FRAME 1

3

ASSY NO	DIMENSION T1 REF	T2 REF	A	B
-417	.190	.190		
-419	.375	.375		
-421				
-423				
-425				
-427				
-429				
-431	.375	.375		

NOTES:

1. UNTRIMMED PANEL WELDMENT TO BE SUPPLIED BY STRUCTURES ENGINEERING. CUT SPECIMEN BLANKS AND TRIM TO SIZES SHOWN ON F/D. LAYOUT OF SPECIMENS ON PANEL WELDMENT TO BE COORDINATED WITH COGNIZANT STRUCTURES ENGINEER.

2. 1.500 WIDTH SECTION TO BE CENTERED ABOUT CL OF #30 DRILL TOOLING HOLES WITHIN .010. THE ENDS OF THE 1.500 WIDTH STRAIGHT PORTION SHALL NOT DIFFER IN WIDTH BY MORE THAN .004. THE WIDTH AT EITHER END OF THIS STRAIGHT PORTION SHALL NOT BE MORE THAN .015 GREATER THAN THE WIDTH AT THE CENTER.

3. ROUND OFF CORNERS AND HAND POLISH PLATE EDGES OVER FULL LENGTH OF REDUCED WIDTH SECTION TO REMOVE ALL NICKS, SCRATCHES AND OTHER IMPERFECTIONS (32/ MIN). DO NOT POLISH OR REMOVE IMPERFECTIONS FROM ANY SPECIMEN FLAT SURFACES.

4. PERMANENTLY IDENTIFY EACH SPECIMEN IN APPROX LOC SHOWN USING MIN 1/4 IN. HIGH CHARACTERS. IDENTIFICATION TO CONSIST OF LAST 3 DIGITS OF DRAWING NO., SPECIMEN DASH NO. AND REPLICATE NO. IN THAT ORDER, i.e. 019-29-2.

5. BREAK ALL SHARP EDGES

PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
-431	C/7	SPECIMEN, BUTT IMPERF	M/F TT802021 - 113	1		
-429			-111			
-427			-109			
-425			-107			
-423			-105			
-421			-103			
-419			-101			
-417			-17			
-415			-15			
-413		SPECIMEN, BUTT IMPERF	M/F TT802021 - 13	1		
-407	C/7	SPECIMEN, BUTT IMPERF	M/F TT802021 -7	1		
-405			-5			
-403			-3			
-401	C/7	SPECIMEN, BUTT IMPERF	M/F TT802021 -1	1		
-315	A/7	SPECIMEN, CRUCIFORM FILLET	M/F TT802017 -115	1		
-313			-113			
-311			-111			
-309			-109			
-307			-107			
-305			-105			
-303			-103			
-301	A/7	SPECIMEN, CRUCIFORM FILLET	M/F TT802017 -101			
-223	B/7	SPECIMEN, TEE FILLET	M/F TT802018 - 25			
-221	B/7	SPECIMEN, TEE FILLET	M/F TT802018 - 23	1		
-213	B/7	SPECIMEN, TEE FILLET	M/F TT802018 - 13	1		
-211			- 11			
-209	B/7	SPECIMEN, TEE FILLET	M/F TT802018 - 9	1		
-205	B/7	SPECIMEN, TEE FILLET	M/F TT802018 - 5	1		
-203			- 3			
-201	B/7	SPECIMEN, TEE FILLET	M/F TT802018 - 1	1		
-121	C/7	S[illegible]N, 2SIDE BUTT	M/F TT802015 - 403	1		
-115	C/7	SPECIMEN, 2 SIDE BUTT	M/F TT802015 - 407	1		
-113			- 505			
-111			- 705			
-109	C/7	SPECIMEN, 2 SIDE BUTT	M/F TT802015 -405	1		
-105	C/7	SPECIMEN, 2SIDE BUTT	M/F TT802015 -501	1		
-103			-701			
-101	C/7	SPECIMEN, 2 SIDE BUTT	M/F TT802015 - 401	1		

PARTS LIST (CONT'D)

PART NUMBER	
-85	C/7
-83	C/7
-75	C/7
-67	C/7
-65	C/7
-51	C/7
-49	
-47	
-45	
-43	
-41	
-39	
-37	
-35	
-33	
-31	
-29	
-27	
-25	
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-21	
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-7	
-5	
-3	
-1	

1

4

LTR	DESCRIPTION
A	INCORPORATED ECR T00087

T TO BE SUPPLIED BY STRUCTURES
BLANKS AND TRIM TO SIZES SHOWN
S ON PANEL WELDMENT TO BE
T STRUCTURES ENGINEER.

CENTERED ABOUT CL OF #30 DRILL
THE ENDS OF THE 1.500 WIDTH
OT DIFFER IN WIDTH BY MORE THAN
END OF THIS STRAIGHT PORTION
.015 GREATER THAN THE WIDTH

D POLISH PLATE EDGES OVER
TH SECTION TO REMOVE ALL NICKS,
RFECTIONS (32 MIN). DO NOT POLISH
OM ANY SPECIMEN FLAT SURFACES.

CH SPECIMEN IN APPROX LOC SHOWN
CTERS. IDENTIFICATION TO CONSIST OF
NO., SPECIMEN DASH NO. AND
i.e. 019-29-2.

PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
-85	C/7	SPECIMEN, 1 SIDE BUTT	M/F TT802015-339	1		
-83	C/7	SPECIMEN, 1 SIDE BUTT	M/F TT802015-337	1		
-75	C/7	SPECIMEN, 1 SIDE BUTT	M/F TT802015-313	1		
-67	C/7	SPECIMEN, 1 SIDE BUTT	M/F TT802015-303	1		
-65	C/7	SPECIMEN, 1 SIDE BUTT	M/F TT802015-3	1		
-51	C/7	SPECIMEN, 1 SIDE BUTT	M/F TT802015-331	1		
-49			-321			
-47			-7			
-45			-111			
-43			-311			
-41			-127			
-39			-327			
-37			-325			
-35			-329			
-33			-15			
-31			-109			
-29			-309			
-27			-9			
-25			-107			
-23			-5			
-21			-119			
-19			-105			
-17			-307			
-15			-113			
-13			-103			
-11			-305			
-9			-333			
-7			-11			
-5			-101			
-3			-301			
-1	C/7	SPECIMEN, 1 SIDE BUTT	M/F TT802015-1	1		

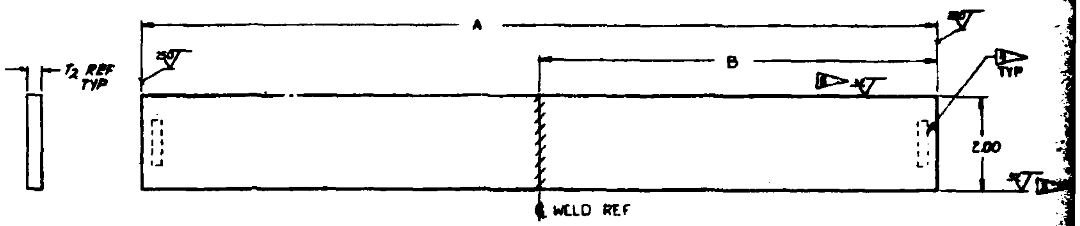
PARTS LIST

DCCU ... RELEASE

TEST SPECIMENS,
WELDED PLATE
TENSILE FATIGUE TEST

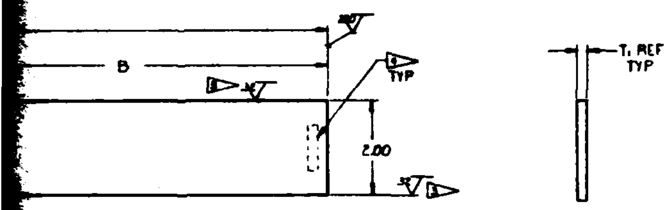
J | TT802019 | A

SCALE NONE



ASS'YS -1 THRU -5, -9 THRU -15, -101

2 1



THRU -15, -101

TABULATION BLOCK						
ASSY NO	A	B	C	D	T_1 REF	T_2 REF
-1	7.0	3.5	—	—	.313	.313
-3			—	—		
-5	7.0	3.5	—	—	.313	.313
-9	7.0	3.5	—	—	.313	.313
-11			—	—		
-13			—	—	.313	
-15	7.0	3.5	—	—	.190	.313
-101	7.0	3.5	—	—	.313	—

TT802020 A

SHT 1

FRAME 2 — FRAME 1

3

4 | 3 | 1 | 2

NOTES.

1. UNTRIMMED PANEL W
STRUCTURES ENGINE
& TRIM TO SIZES SH
ON PANEL WELDMENT
STRUCTURES ENGINE

2. BREAK SHARP EDGES

3. ROUND-OFF & HAND P
SPECIMEN TO REMOVE
IMPERFECTIONS(
IMPERFECTIONS FROM

4. PERMANENTLY IDENTIF
LOCATIONS SHOWN US
IDENTIFICATION TO CO
NUMBER, SPECIMEN D
IN THAT ORDER ie. O

5. ABBREVIATIONS PER M

02020 A

FRAME 2 ← → FRAME 1

4 | 3 | 1 | 2

A	INCORPORATED ECRT00067		

NOTES:

1. UNTRIMMED PANEL WELDMENT TO BE SUPPLIED BY STRUCTURES ENGINEERING. CUT SPECIMEN BLANKS & TRIM TO SIZES SHOWN ON F/D. LAYOUT OF SPECIMENS ON PANEL WELDMENT TO BE COORDINATED WITH COGNIZANT STRUCTURES ENGINEER
2. BREAK SHARP EDGES ON ALL SPECIMENS
3. ROUND-OFF & HAND POLISH EDGES OVER FULL LENGTH OF SPECIMEN TO REMOVE ALL NICKS SCRATCHES AND OTHER IMPERFECTIONS (8√ MIN). DO NOT POLISH OR REMOVE IMPERFECTIONS FROM ANY SPECIMEN FLAT SURFACES.
4. PERMANENTLY IDENTIFY EACH SPECIMEN IN APPROXIMATE LOCATIONS SHOWN USING 1/4 MINIMUM HIGH CHARACTERS. IDENTIFICATION TO CONSIST OF LAST 3 DIGITS OF DRAWING NUMBER, SPECIMEN DASH NUMBER & REPLICATE NUMBER IN THAT ORDER ie. 020-11-2
5. ABBREVIATIONS PER MIL-STD-12

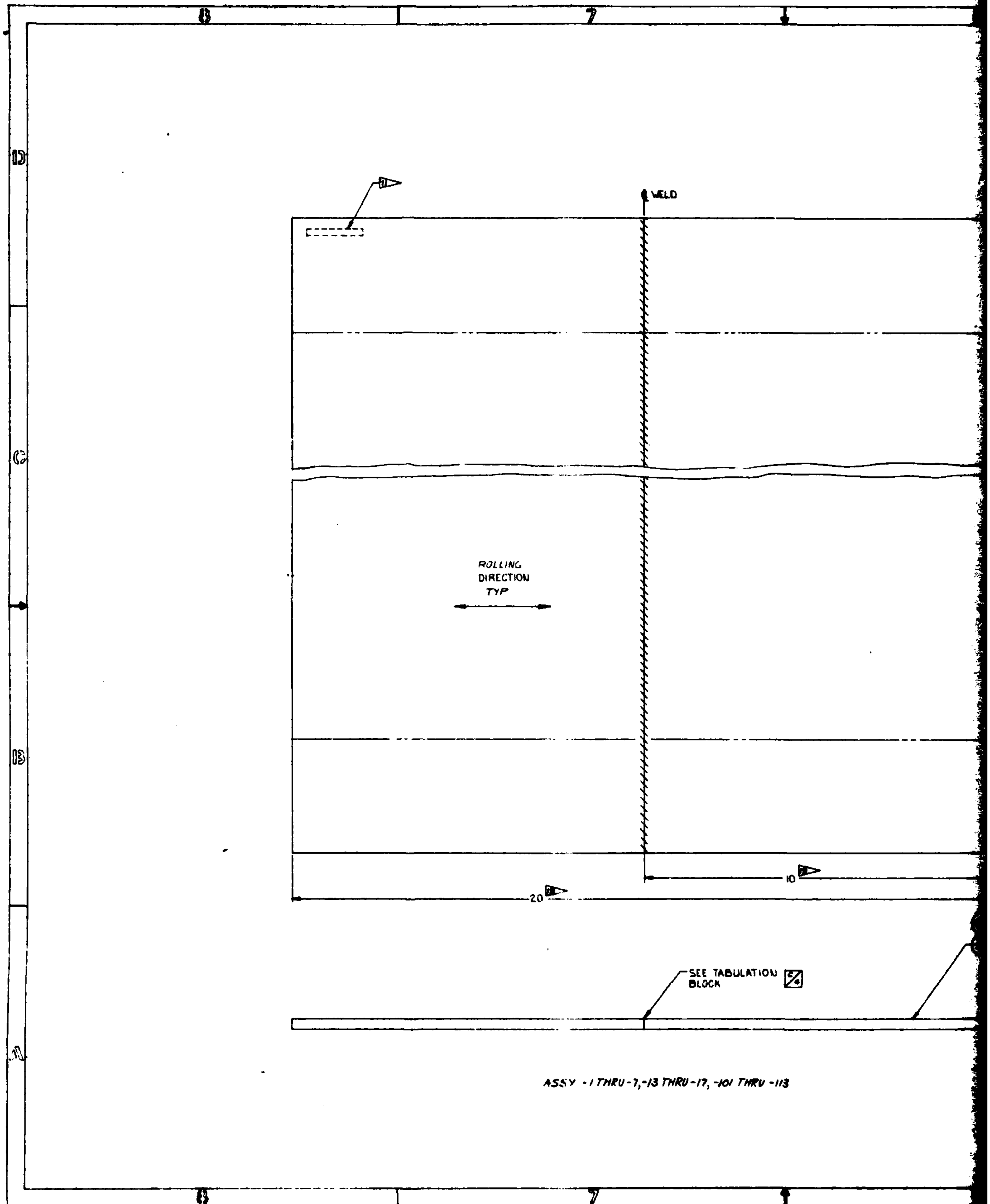
PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
-101		SPECIMEN 2-SIDE BUTT	M/F TT802015 - 401	1		
-15		SPECIMEN 1-SIDE BUTT	M/F TT802015 - 121	1		
-13			- 317			
-11			- 313			
-9		SPECIMEN 1-SIDE BUTT	M/F TT802015 - 303	1		
-5		SPECIMEN 1-SIDE BUTT	M/F TT802015 - [illegible]	1		
-3			- 307			
-1		SPECIMEN 1-SIDE BUTT	M/F TT802015 - 301	1		

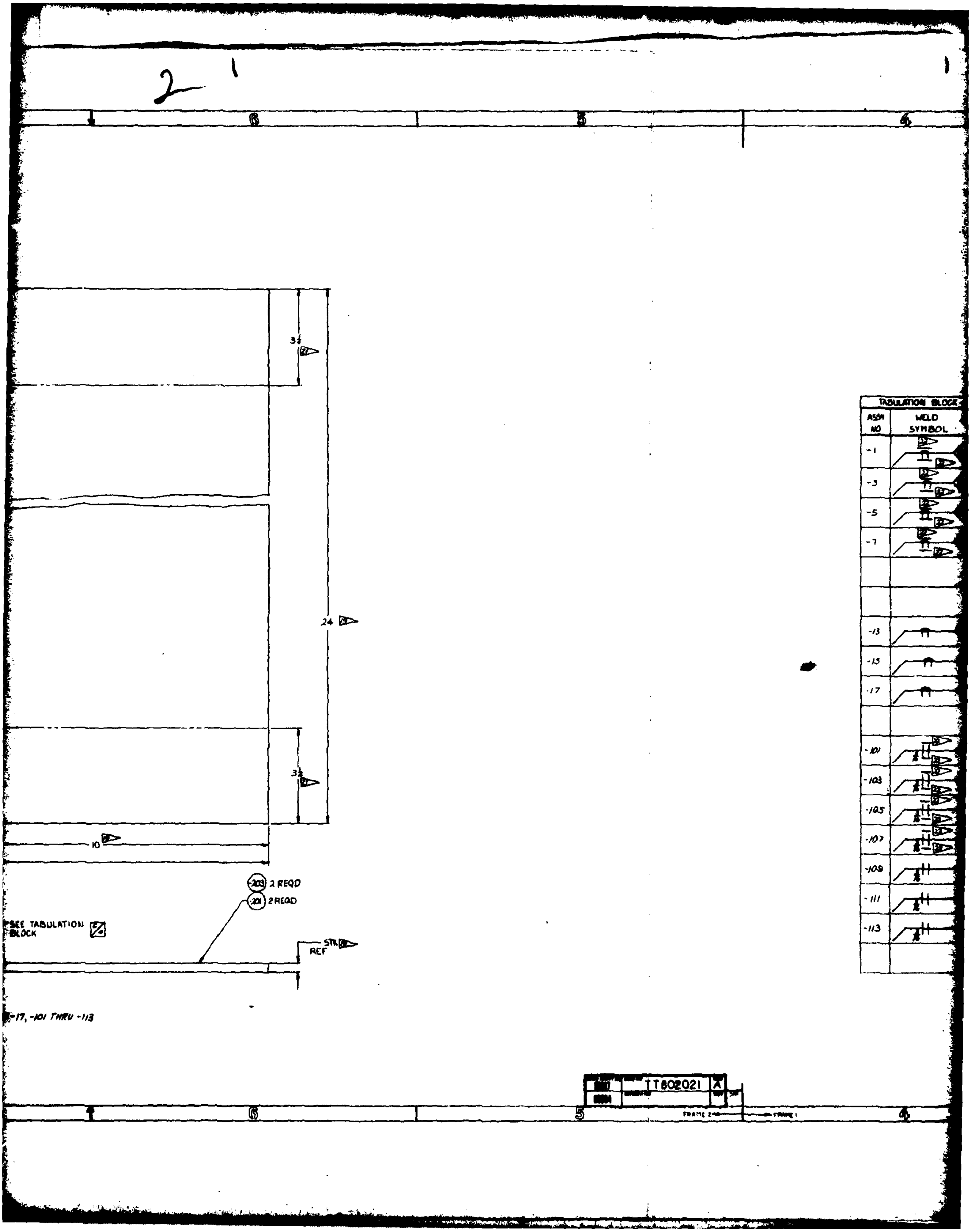
PARTS LIST

DOCUMENT RELEASE

TEST SPECIMEN-
WELDED PLATE,
BENDING FATIGUE TEST

J | TT802020 | A


8
7
D
C
B
A
WELD
ROLLING
DIRECTION
TYP
10
20
SEE TABULATION
BLOCK
ASSY -1 THRU -7, -13 THRU -17, -101 THRU -113



2
6
5
4
3½
24
10
-203 2 REQD
-201 2 REQD
SEE TABULATION BLOCK
STR REF
-17, -101 THRU -113
TABULATION BLOCK
ASSY NO
WELD SYMBOL
-1
-3
-5
-7
-13
-15
-17
-101
-103
-105
-107
-109
-111
-113
T802021
A
FRAME 2
FRAME 1

3

4 | 3 | 2

TABULATION BLOCK	
ASSY NO	WELD SYMBOL
-1	
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-15	
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-101	
-103	
-105	
-107	
-109	
-111	
-113	

11. PERMANENTLY IDENTIFY EACH ASSEMBLY IN APPROXIMATE LOCATION SHOWN USING 1/4 MIN HIGH CHARACTERS. IDENT TO CONSIST OF LAST 3 DIGITS OF DRAWING NO. FOLLOWED BY ASSEMBLY DASH NO, i.e. 021-7

12. PANEL SURFACE FLATNESS SHALL NOT DEVIATE MORE THAN .250 TIR FROM A FLAT PLANE ESTABLISHED BY HEIGHT BLOCKS LOCATED 1 IN FROM THE EDGES AT ALL 4 CORNERS OF THE PANEL WELDMENT WITH HAND PRESSURE APPLIED AT ANY CORNER NECESSARY TO PRODUCE CONTACT.

13. AS A GOAL WELD SHOULD CONTAIN POROSITY (AS DETERMINED FROM RADIOGRAPHIC INSPECTIONS) WITH THE TOTAL AREA OF POROSITY PER INCH OF WELD LENGTH TO BE IN THE RANGE FROM 2.35 TO 5% OF THE BASE METAL THICKNESS.

14. SAME AS 13 EXCEPT AREA OF POROSITY PER INCH OF WELD LENGTH TO BE FROM 5 TO 7.5% OF THE BASE METAL THICKNESS.

15. AS A GOAL WELD SHOULD CONTAIN LACK OF PENETRATION OR LACK OF FUSION INDICATIONS EACH 1/16 LONG SPACED AT 3 1/4 OR GREATER PITCH ALONG LENGTH OF WELD.

16. SAME AS 15 EXCEPT EACH INDICATION TO BE 1/32 LONG.

17. SAME AS 15 EXCEPT EACH INDICATION TO BE 1/8 LONG.

19. NOTED DIMENSIONS & MATERIAL THICKNESS MAY BE ALTERED WITH APPROVAL OF THE COGNIZANT STRUCTURES ENGINEER

20. WELD . TEST ASSEMBLIES SELECTED FROM THE 3KSES WELDING PROCEDURES DEVELOPEMENT PROGRAM FOR THE SAME JOINT DESIGNS WHICH CONTAIN IMPERFECTIONS OF THE APPROXIMATE TYPES & DEGREES AS DEFINED IN 13 14 15 16 & 17 . MAY BE SUPPLIED AS ALTERNATES TO ANY DASH NO. WELD ASSEMBLY.

21. WELD RUNOUT ALLOWANCE.

22. REMOVE FRONT AND BACK FACE WELD BEAD REINFORCEMENTS BY SHAVING FLUSH TO .030 ABOVE MATERIAL SURFACE ON HIGHER SIDE OF JOINT PER PLANNED 3KSES PRODUCTION PROCEDURES. DO NOT GRIND. DO NOT SHAVE WHEN WELD BEAD REINFORCEMENT IS BELOW MATERIAL SURFACE ON ONE SIDE OF THE JOINT.

NOTES:

1. BREAK ALL SHARP ED[illegible]
2. UNLESS OTHERWISE SPEC[illegible] INSPECTION TO BE PER[illegible]
3. WELD SYMBOLS PER [illegible]
4. ALL WELDING MUST BE [illegible] OF THE SAME JOINT CONF[illegible] TO PRODUCE THE SPEC[illegible]
5. NO WELD REPAIRS O[illegible] PERMISSIBLE
6. POST WELD STRAIGHTENI[illegible] MEET SPECIFIED DRAWI[illegible] PROCEDURES TO BE F[illegible] BEFORE & AFTER CON[illegible]
7. ALL FABRICATION PROC[illegible] ENGINEERING REFER[illegible]
8. ALL WELDS TO BE 100% [illegible] ACCEPTANCE CRITERIA [illegible] STRUCTURES ENGINEE[illegible]
9. 100% RADIOGRAPHIC INS[illegible] PERFORMED PER MIL-[illegible] NORMAL AND 45° IN[illegible]
10. ALL INSPECTIONS TO [illegible] PROCEDURES & DETA[illegible] OF ALL IMPERFECTIONS [illegible] CLASS 3 & NAVSEA 09[illegible]

-113	-111	-109	-107	-105	-103	-101	-17	-15	-13			-7	-5	-3	-1	PART NUMBER
2	2	2	2	2	2	2										-[illegible]
							2	2	2			2	2	2	2	-[illegible]
-																-113
	-															-111
		-														-109
			-													-107
				-												-105
					-											-103
						-										-101
							-									-17
								-								-15
									-							-13
												-				-7
													-			-5
														-		-3
															-	-1
									QUANTITY							

4 | 3 | 2

4

LTR	DESCRIPTION
A	INCORPORATED ECR T00067[illegible]

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OSITY PER INCH OF
THE BASE METAL THICKNESS.
LD LENGTH TO BE FROM

ACK OF FUSION
ALONG LENGTH OF WELD.

ED
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E
OR
S

ATES

EMENTS BY
ON HIGHER SIDE
CEDURES. DO NOT
MENT IS BELOW

NOTES:

1. BREAK ALL SHARP EDGES
2. UNLESS OTHERWISE SPECIFIED, FABRICATION, WELDING & INSPECTION TO BE PER NAVSEA 0900-LP-060-4010
3. WELD SYMBOLS PER AWS-A-2.0
4. ALL WELDING MUST BE PER PROCEDURES QUALIFIED FOR 3KSES PRODUCTION OF THE SAME JOINT CONFIGURATION, EXCEPT AS MODIFIED TO PRODUCE THE SPECIFIED WELD IMPERFECTIONS
5. NO WELD REPAIRS OF WELD IMPERFECTIONS ARE PERMISSIBLE
6. POST WELD STRAIGHTENING (IF REQD) SHALL BE MINIMUM NECESSARY TO MEET SPECIFIED DRAWING TOLERANCES. ALL STRAIGHTENING PROCEDURES TO BE FULLY DOCUMENTED INCLUDING BEFORE & AFTER CONDITIONS.
7. ALL FABRICATION PROCEDURES TO BE DOCUMENTED FOR ENGINEERING REFERENCE.
8. ALL WELDS TO BE 100% VISUAL & PENETRANT INSPECTED ACCEPTANCE CRITERIA TO BE SPECIFIED BY COGNIZANT STRUCTURES ENGINEER. USE GROUP III LIQUID PENETRANT ONLY.
9. 100% RADIOGRAPHIC INSPECTION OF ALL WELDS TO BE PERFORMED PER MIL-STD-271 WITH VIEWS TO BE TAKEN AT BOTH NORMAL AND 45° INCIDENCES.
10. ALL INSPECTIONS TO BE FULLY DOCUMENTED, INCLUDING PROCEDURES & DETAILED NATURE, SIZES & LOCATIONS OF ALL IMPERFECTIONS EXCEEDING NAVSEA 0900-LP-003-8000 CLASS 3 & NAVSEA 0900-LP-003-9000 CLASS 3 STANDARDS

-103	-101	-17	-15	-13			-7	-5	-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
2	2										-2[illegible]		PLATE	AL ALY 5456 H116/117	.375×10×24	QQ-A-250/20	
		2	2	2			2	2	2	2	-2[illegible]		PLATE	AL ALY 5456 H116/117	.190×10×24	QQ-A-250/20	
											-113		WELD ASSY				
											-111						
											-109						
											-107						
											-105						
-											-103						
	-									-	-101		WELD ASSY				
		-									-17		WELD ASSY				
			-								-15						
				-							-13		WELD ASSY				
							-				-7		WELD ASSY				
								-			-5						
									-		-3						
										-	-1		WELD ASSY				

QUANTITY

PARTS LIST

DOCUMENT RELEASE

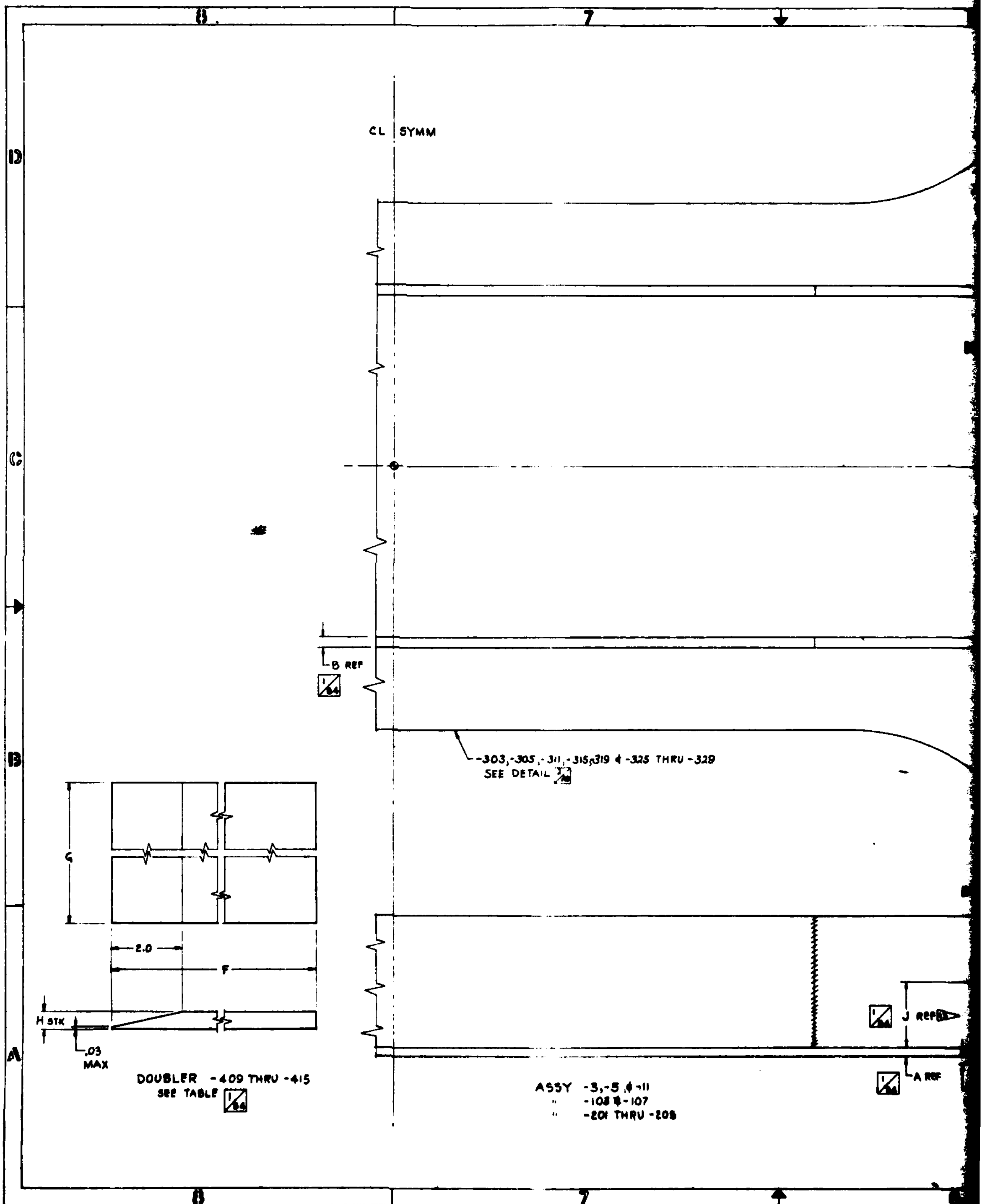
PLATE WELDMENT - TRANSVERSE BUTT WELD IMPERFECTIONS, STRUCTURAL TEST

3KSES

J

TT802021

A


CL SYMM
B REF
-303,-305,-311,-315,-319 & -325 THRU -329
SEE DETAIL
G
2.0
F
H STK
.03 MAX
DOUBLER -409 THRU -415
SEE TABLE
ASSY -3,-5 & -11
" -103 & -107
" -201 THRU -205
J REF
A REF

1.

2

(NOTES CONT'D)

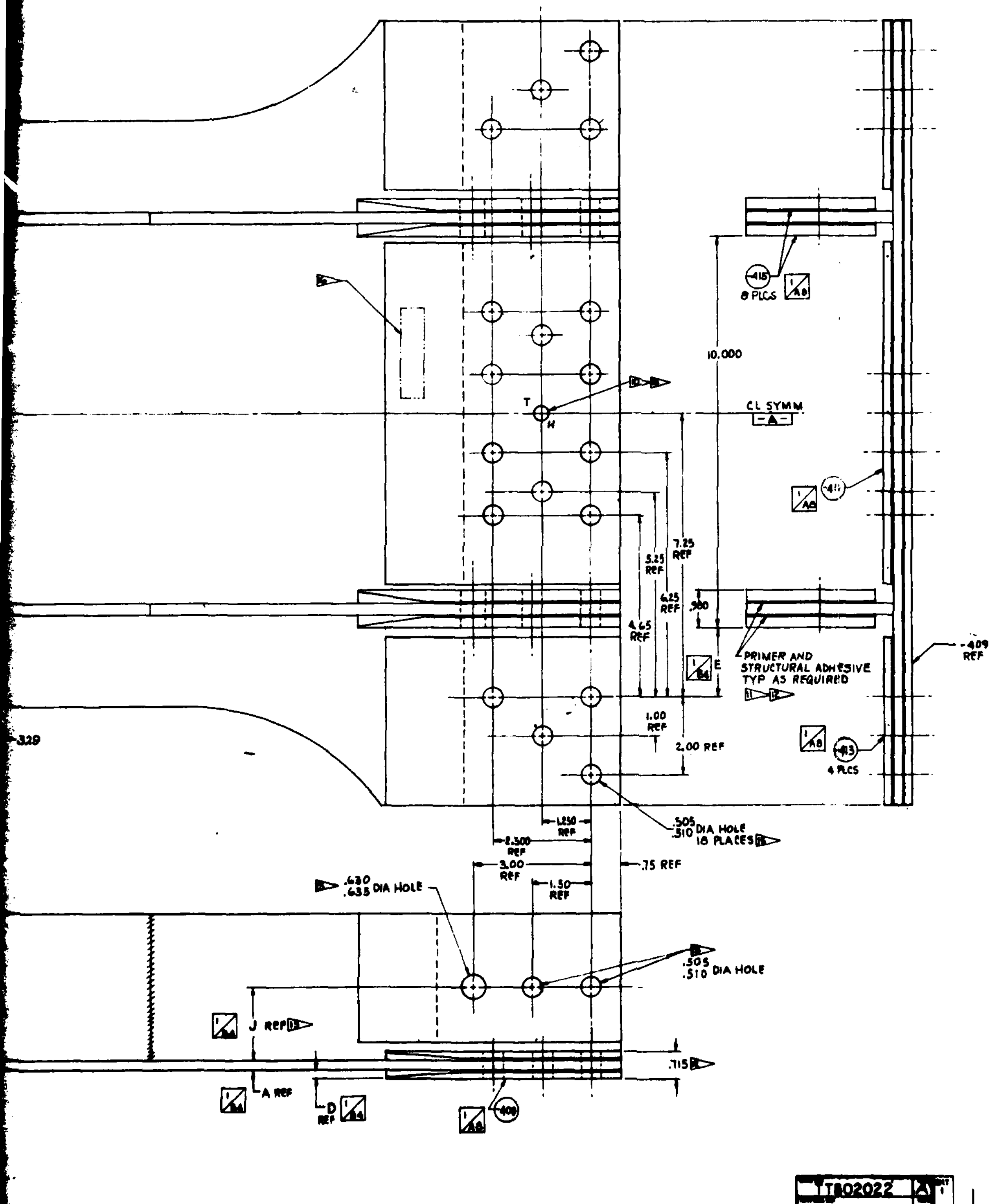
15. SMALL QUANTITIES OF CAB-O-SIL (CABOT CO[illegible] BE ADDED TO ADHESIVE TO INCREASE VISCOSIT[illegible] EASE OF HANDLING.

16. HYSOL DIVISION, THE DEXTER CORP, LOS A[illegible]

17. USING THE TWO TOOLING HOLES 'T⊕H' AT [illegible] END OF THE SPECIMEN, LOCATE AND DRILL [illegible] REMAINING END FIXTURE ATTACHMENT HO[illegible] EACH END OF SPECIMEN USING DRILL FI[illegible] NO. TTB02029. ADD SPACERS AND O[illegible] AS REQUIRED TO TOOLING FIXTURE TO SET [illegible] DIMENSION PROVIDED BY COGNIZANT STR[illegible] ENGINEER. DO NOT USE 'J' REF TABULATED [illegible]

18. PERMANENTLY IDENTIFY EACH SPECIMEN [illegible] APPROX LOCATION SHOWN USING 1/4 HIGH [illegible] CHARACTERS. IDENT TO CONSIST OF LAST [illegible] OF DRAWING NO., SPECIMEN DASH NO., 'S' FO[illegible] TEST OR 'F' FOR FATIGUE TEST, AND REPLI[illegible] NO. e.g. 022-201-FZ.

19. DOUBLER MATERIAL AND GAGE SUBSTI[illegible] ARE PERMITTED WITH APPROVAL OF COGN[illegible] STRUCTURES ENGINEER.



DIMENSION TABLE						
DASH NO.	A REF	B REF	C REF	D REF	E	F
-3	.250	.313	3.75	.232	1.760	–
-5	.250	.313	3.95	.232	1.760	–
-11	.250	.313	3.75	.232	1.760	–
-105	.250	.313	3.75	.232	1.760	–
-107	.250	.313	3.75	.232	1.760	–
-201	.250	.313	3.75	.232	1.760	–
-203	.250	.313	3.75	.232	1.760	–
-205	.250	.313	3.75	.232	1.760	–
-409	–	–	–	–	–	6.0
-411	–	–	–	–	–	6.0
-413	–	–	–	–	–	6.0
-415	–	–	–	–	–	6.3

TT802022 A

3

(NOTES CONT'D)

13. SMALL QUANTITIES OF CAB-O-SIL (CABOT CORP.) MAY BE ADDED TO ADHESIVE TO INCREASE VISCOSITY FOR EASE OF HANDLING.

14. HYSOL DIVISION, THE DEXTER CORP, LOS ANGELES, CA.

15. USING THE TWO TOOLING HOLES 'T⌖H' AT EACH END OF THE SPECIMEN, LOCATE AND DRILL ALL REMAINING END FIXTURE ATTACHMENT HOLES IN EACH END OF SPECIMEN USING DRILL FIXTURE NO. TT802029. ADD SPACERS AND OR SHIMS AS REQUIRED TO TOOLING FIXTURE TO SET 'J' REF DIMENSION PROVIDED BY COGNIZANT STRUCTURES ENGINEER. DO NOT USE 'J' REF TABULATED ON F/D.

16. PERMANENTLY IDENTIFY EACH SPECIMEN IN APPROX LOCATION SHOWN USING 1/4 HIGH MIN CHARACTERS. IDENT TO CONSIST OF LAST 3 DIGITS OF DRAWING NO., SPECIMEN DASH NO., 'S' FOR STATIC TEST OR 'F' FOR FATIGUE TEST, AND REPLICATE NO. e.g. 022-201-FZ.

17. DOUBLER MATERIAL AND GAGE SUBSTITUTIONS ARE PERMITTED WITH APPROVAL OF COGNIZANT STRUCTURES ENGINEER.

NOTES:

1. TT802024 LARGE ASSEMBLIES TO BE SUPPLIED BY STRUCTURES ENGINEERING. CUT SPECIMEN BLANKS AND TRIM TO SIZES SHOWN ON F/D. LAYOUT OF SPECIMEN BLANKS TO BE COORDINATED WITH COGNIZANT STRUCTURES ENGINEER.

2. BREAK SHARP EDGES. DO NOT FINISH, POLISH OR REMOVE IMPERFECTIONS FROM ANY SPECIMEN FLAT SURFACES.

3. STATIC TEST SPECIMENS ONLY.

4. FATIGUE TEST SPECIMENS ONLY - ROUND OFF CORNERS AND HAND POLISH PLATE EDGES OVER FULL LENGTH OF REDUCED WIDTH SECTION TO REMOVE ALL NICKS, SCRATCHES AND OTHER IMPERFECTIONS (32 MIN).

5. DESIGNATION OF STATIC TEST AND FATIGUE TEST SPECIMENS TO BE OBTAINED FROM COGNIZANT STRUCTURES ENGINEER.

6. IDENTIFY EACH PANEL IN APPROX LOCATION SHOWN USING INK MARKINGS WITH 1/4 MIN HIGH CHARACTERS. IDENT TO CONSIST OF LAST 3 DIGITS OF DRAWING NO, PANEL DASH NO. AND 'S' FOR STATIC TEST OR 'F' FOR FATIGUE TEST, i.e. 022-503-S

7. DATUM -A- TO BE CENTERED WITHIN .010 BETWEEN STIFFENER BASE INNER FACES (ABOVE FILLET WELD BEADS) AT EACH END OF TRIMMED PANEL. USING A STRAIGHT EDGE CONNECTING THE LOCATED END POINTS, LIGHTLY SCRIBE 8.0 LENGTH LINES ON STIFFENER SIDE OF PLATE STARTING AT EACH END OF PANEL. DRILL TWO .375/.377 TOOLING HOLES LOCATED AS SHOWN.

8. .3751/.3755 DIA TOOLING HOLE LOCATED AS SHOWN.

9. USE DRILL FIXTURE NO. TT802028 TO LOCATE AND DRILL .3751/.3755 DIA TOOLING HOLE.

10. BEFORE BONDING DOUBLERS, LOCATE AND DRILL .375/.380 DIA HOLES IN -409 & -411. DOUBLERS TO MATCH LOCATION OF PANEL TOOLING HOLES 'T⌖H'.

11. PREPARE DOUBLERS AND PANEL ENDS FOR BONDING IN ACCORDANCE WITH ROHR MPD 02004. WITHIN 1 HOUR AFTER CLEANING, APPLY A THIN COATING OF PRIMER TO BONDING SURFACES AND DRY 1 HOUR AT 75°F. APPLY PRIMER AS RECEIVED ONLY SUFFICIENT TO WET THE BOND SURFACES.

12. BOND PRIMED DOUBLERS TO PRIMED SPECIMEN PER ADHESIVE MANUFACTURERS INSTRUCTIONS - MAINTAIN THICKNESS AND LOCATION DIMENSIONS SHOWN ON F/D USING TOOLING AS REQUIRED.

-409 REF

DIMENSION TABLE

DASH NO.	A REF	B REF	C REF	D REF	E	F	G	H STK	J REF
-						–	–	–	1.25
-3	.250	.313	3.75	.232	1.760	–	–	–	1.87
-5	.250	.313	3.75	.232	1.760	–	–	–	1.87
-11	.250	.313	3.75	.232	1.760	–	–	–	1.87
-105	.250	.313	3.75	.232	1.760	–	–	–	1.87
-107	.250	.313	3.75	.232	1.760	–	–	–	1.87
-201	.250	.313	3.75	.232	1.760	–	–	–	1.87
-203	.250	.313	3.75	.232	1.760	–	–	–	1.87
-205	.250	.313	3.75	.232	1.760	–	–	–	1.87
-409	–	–	–	–	–	6.0	20.0	.200	–
-411	–	–	–	–	–	6.0	8.7	.200	–
-413	–	–	–	–	–	6.0	4.3	.200	–
-415	–	–	–	–	–	6.7	3.3	.25	–

QUANTITY REQUIRED PER ASSEMBLY

PART NUMB

PARTS LI

REVISION STATUS OF SHEETS

4

A	INCORPORATED ECR T00080		

PART NUMBER	SHT / ZN	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
		PRIMER	HYSOL EA 9203		15	
		ADHESIVE	HYSOL EA 9309.2		16	15
-415	1	DOUBLER 17	7075-T651 AL ALY	.250×3.3×6.7	QQ-A-250/12	
-413	1		7075-T6	.200×4.3×6.0		
-411	1			.200×8.7×6.0		
-409	1	DOUBLER 17	7075-T6 AL ALY	.200×20.0×6.0	QQ-A-250/12	
-329	2	PANEL, TRIM	M/F TT802024-57	1		
-327	2	PANEL, TRIM	M/F TT802024-63	1		
-325	2	PANEL, TRIM	M/F TT802024-59	1		
-319	2	PANEL, TRIM	M/F TT802024-53	1		
-315	2	PANEL, TRIM	M/F TT802024-51	1		
-311	2	PANEL, TRIM	M/F TT802024-41	1		
-305	2	PANEL, TRIM	M/F TT802024-9	1		
-303	2	PANEL, TRIM	M/F TT802024-1	1		
-205	1	PANEL ASSY				
-203	1					
-201	1	PANEL ASSY				
-107	1	PANEL ASSY				
-105	1	PANEL ASSY				
-11	1	PANEL ASSY				
-5	1	PANEL ASSY				
-3	1	PANEL ASSY				

QUANTITY REQUIRED PER ASSEMBLY

PARTS LIST

REVISION STATUS OF SHEETS	REV.	A	A
	SHEET	1	2

DOCUMENT RELEASE

TEST ARTICLE ASSYS-
STIFFENED PANEL,
TENSILE STATIC &
FATIGUE TESTS

J TT802022 A

AD-A087 437 ROHR MARINE INC NATIONAL CITY CA F/G 13/10
SURFACE EFFECT SHIP STRUCTURAL PRODUCIBILITY. PART II.(U)
MAY 80 N00024-77-C-2023

UNCLASSIFIED NL

6 of 6
AD A
087437

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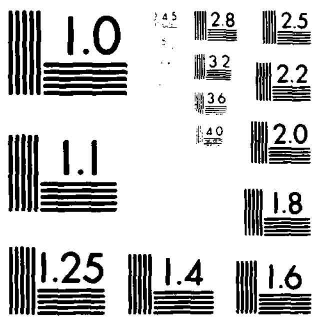
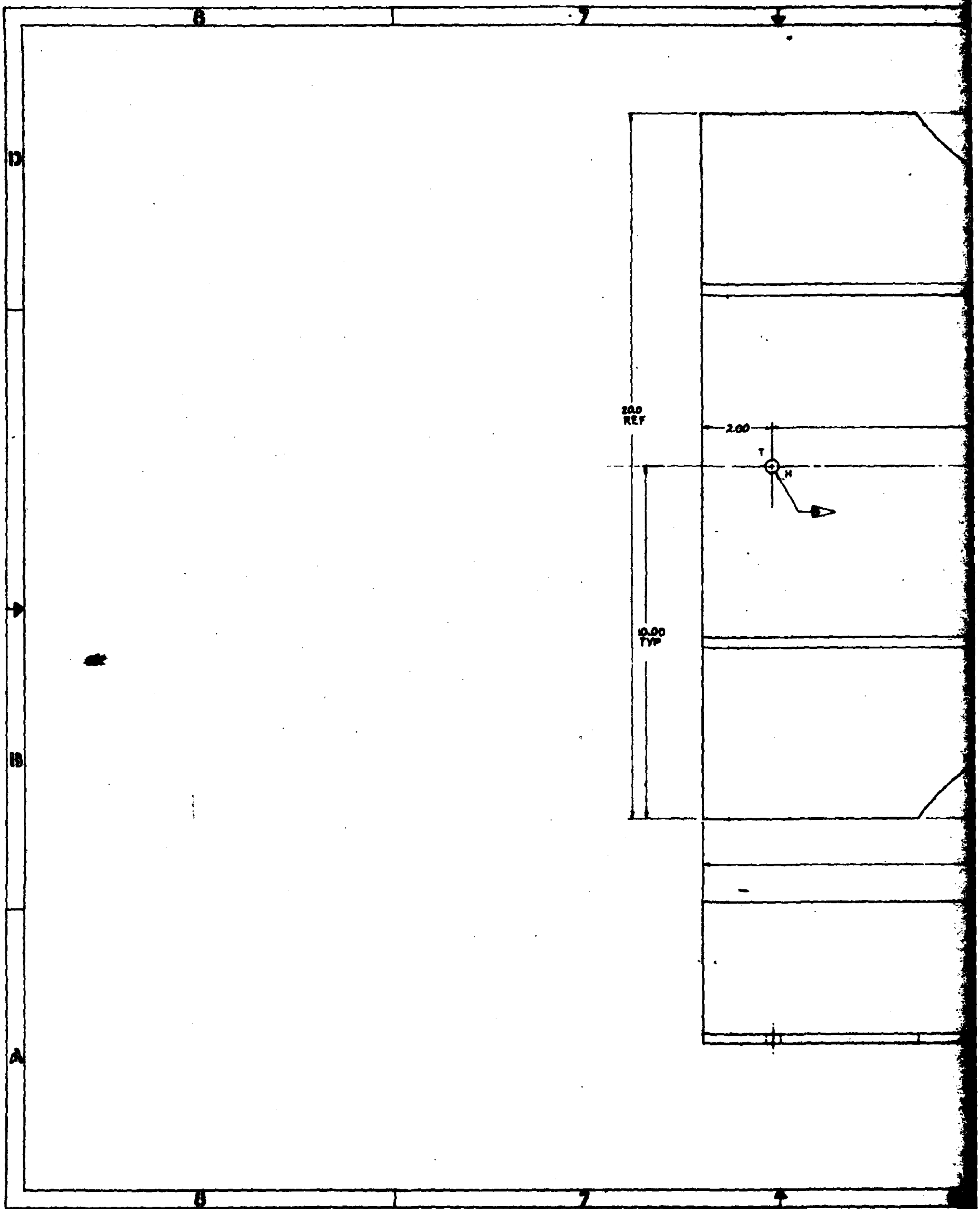
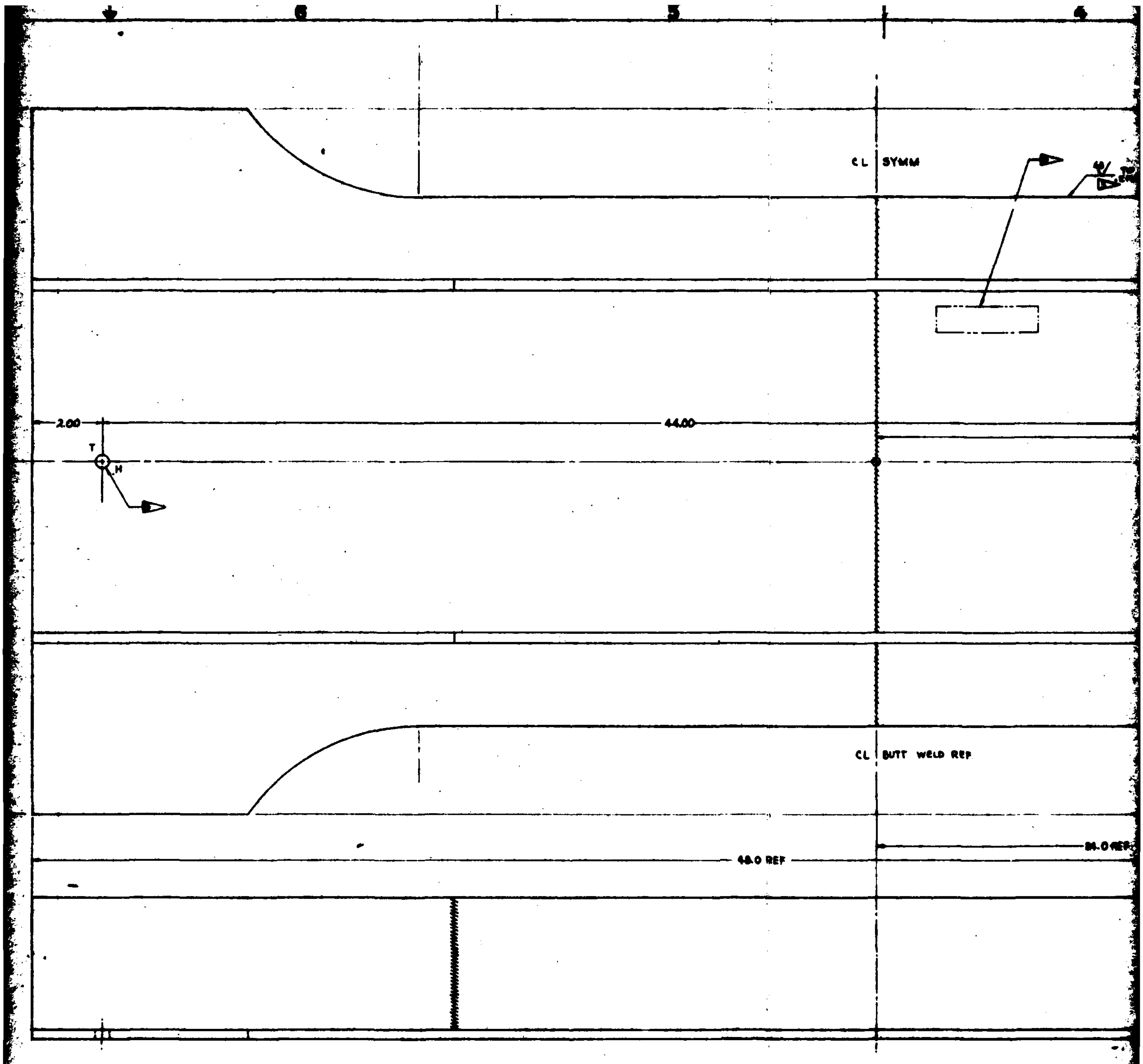


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

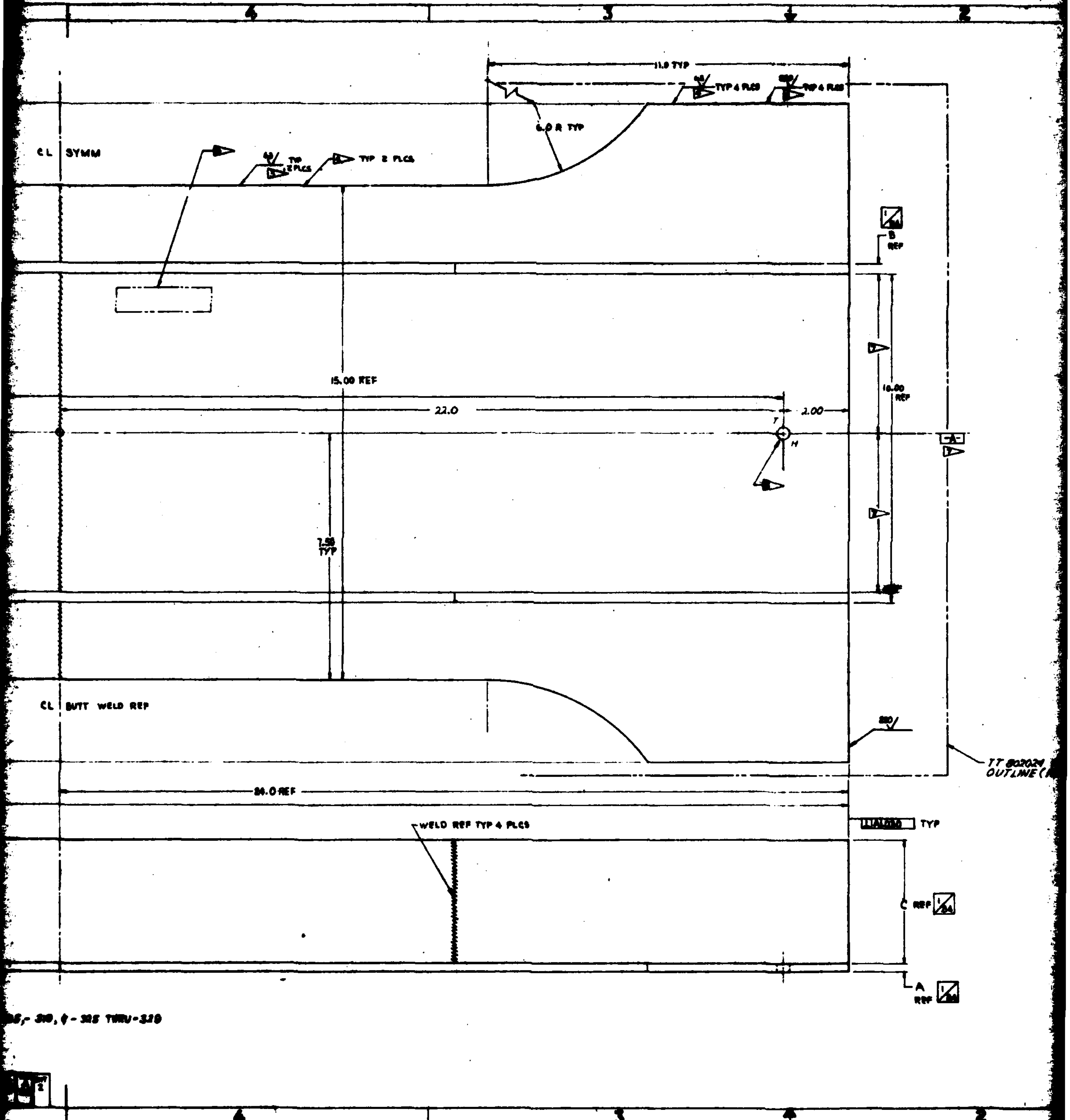

8
7
D
B
A
20.0 REF
2.00
T
H
10.00 TYP



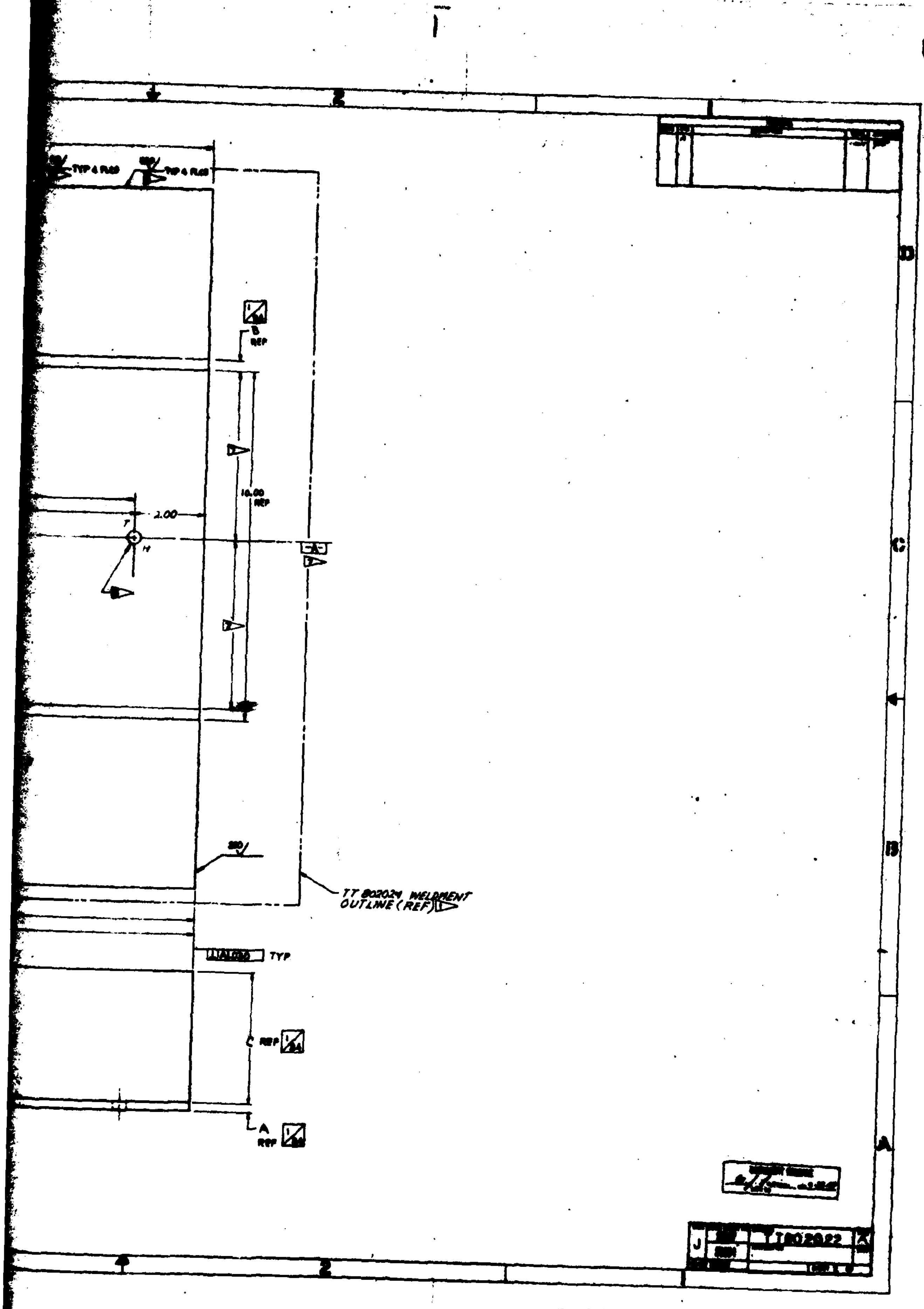
PANEL, TRIM -303, -305, -311, -315, -319, & -325 THRU -328

1802022 A 2

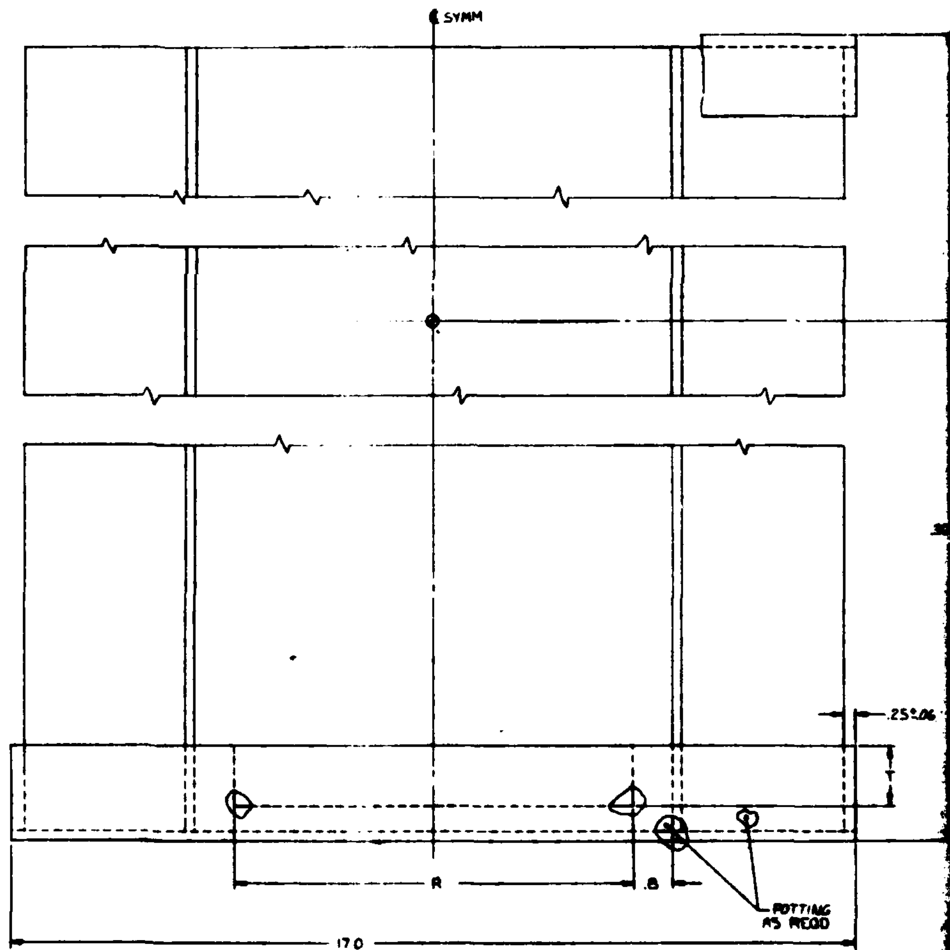
3 1



-305, -310, & -325 THRU -330



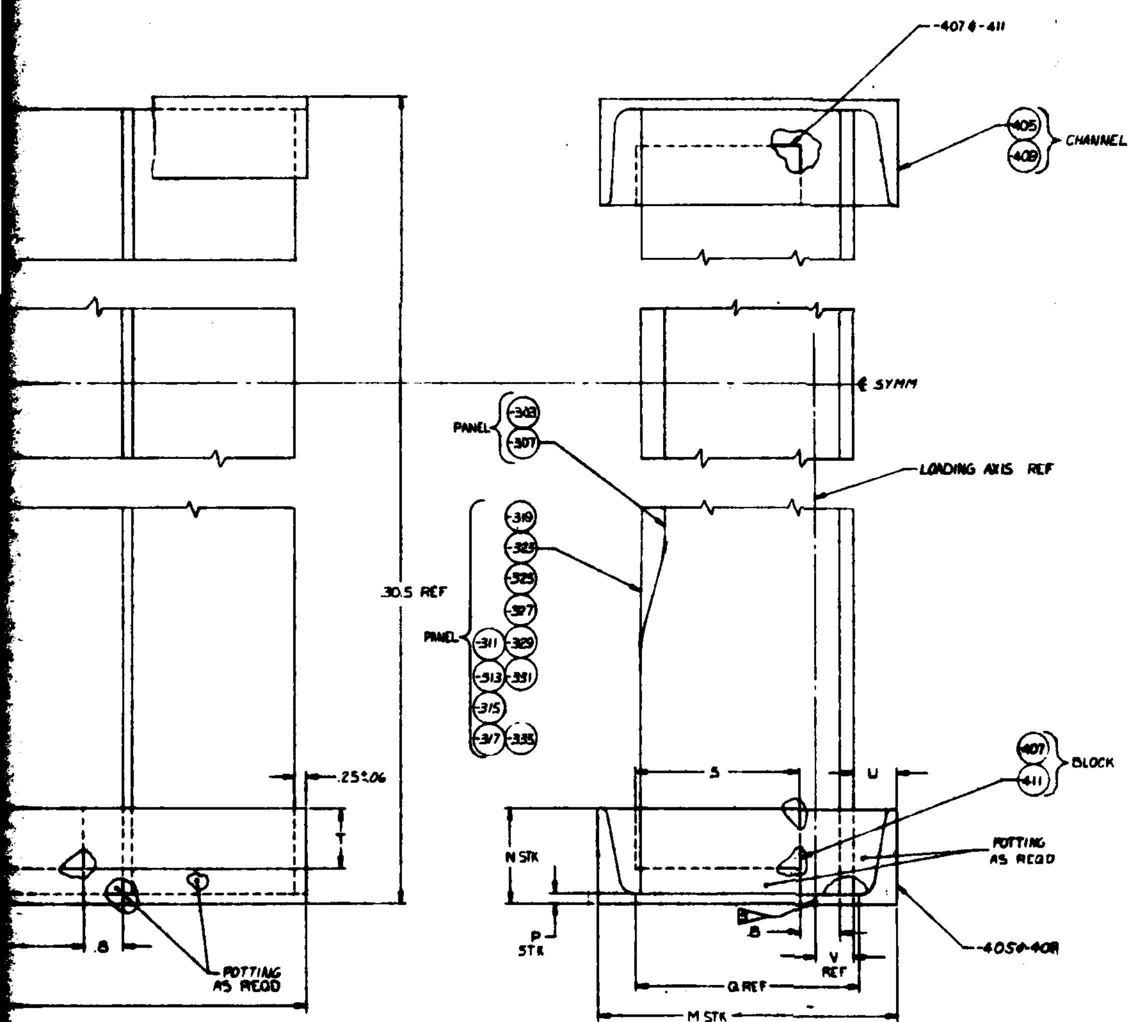
4
TYP 4 PLCS
B
REF
10.00
REF
2.00
A
TT 802024 WELDMENT
OUTLINE (REF)
TYP
C REF
A
REF
D
C
B
A
J
TT802022



ASSY -3,+74 -11
ASSY -101 THRU -107 & -111
ASSY -201 THRU -207 & -211

SEE TABLE
FOR TABULATED DIMENSIONS

2 1 1



PANEL ASS			
ASSY NO	M STK	N STK	P STK
-3	6.0	2.034	.314
-7	6.0	2.034	.314
-11	6.0	2.034	.314
-101	6.0	2.034	.314
-103			
-105			
-107	6.0	2.034	.314
-111	6.0	2.034	.314
-201	7.0	2.299	.419
-203			
-205			
-207	7.0	2.299	.419
-211	7.0	2.299	.419

TT802023 A

3

4	3	2

▷ DIMENSIONS SHOWN MAY BE ALTERED TO SUIT STOCK SIZE. MAINTAIN .75 MINIMUM POTTING THICKNESS BETWEEN WOOD & PANEL SPECIMEN AT ALL LOCATIONS; MAINTAIN APPROXIMATELY .5 MINIMUM POTTING THICKNESS BETWEEN WOOD & END CHANNELS AT ALL LOCATIONS.

▷ MFG BY DEVCON CORP, DANVERS, MASS.

NOTES

1. BREAK ALL SHARP EDGES

▷ LARGE PANEL WELDMENT TO BE S
STRUCTURES ENGINEERING. CUT
BLANKS & TRIM AS SHOWN ON F/D.
TEST PANEL LOCATIONS ON LARGE
WELDMENT TO BE COORDINATED WI
STRUCTURES ENGINEER.

▷ ALTERNATE HARDWOOD MAY BE SUB
APPROVAL OF COGNIZANT STRUCTURES

▷ FOLLOW MFG RECOMMENDATIONS F
PREP OF SPECIMEN, MIXING, CURE

▷ SCRIBE LOCATION OF LOADING AXIS O
CHANNELS -405, & -409 AFTE
USE "V" DIMENSION OBTAINED FROM
STRUCTURES ENGINEER; DO NOT
TABULATED ON F/D.

NOTES CONTINUED NEXT

PANEL ASSY DIMENSIONS

ASSY NO	M STK	N STK	P STK	Q REF	R	S	T	U	V REF
-3	6.0	2.034	.314	4.50	8.0	3.3	1.2	.9	.711
-7	6.0	2.034	.314	4.50	8.0	3.3	1.2	.9	.711
-11	6.0	2.034	.314	4.50	8.0	3.3	1.2	.9	786
-101	6.0	2.034	.314	4.50	8.0	3.3	1.2	.9	.588
-103									
-105									
-107	6.0	2.034	.314	4.50	8.0	3.3	1.2	.9	.588
-111	6.0	2.034	.314	4.50	8.0	3.3	1.2	.9	.588
-201	7.0	2.299	.419	5.5	7.9	4.5	1.3	.85	.892
-203									
-205									
-207	7.0	2.299	.419	5.5	7.9	4.5	1.3	.85	.892
-211	7.0	2.299	.419	5.5	7.9	4.5	1.3	.85	.892

-211	-209	-207	-205	-203	-201	-111	-107	-105	-103	-101	-11	-7	-3	PART NUMBER

PARTS LIST

DOCUMENT RELEASE

4	3	2

4

NOTES

1. BREAK ALL SHARP EDGES

2. LARGE PANEL WELDMENT TO BE SUPPLIED BY STRUCTURES ENGINEERING. CUT TEST PANEL BLANKS & TRIM AS SHOWN ON F/D. LAYOUT OF TEST PANEL LOCATIONS ON LARGE PANEL WELDMENT TO BE COORDINATED WITH COGNIZANT STRUCTURES ENGINEER.

3. ALTERNATE HARDWOOD MAY BE SUBSTITUTED WITH APPROVAL OF COGNIZANT STRUCTURES ENGINEER

4. FOLLOW MFG RECOMMENDATIONS FOR SURFACE PREP OF SPECIMEN, MIXING, CURE TIMES, ETC.

5. SCRIBE LOCATION OF LOADING AXIS ON BOTH ENDS OF CHANNELS -405, & -409 AFTER POTTING. USE "V" DIMENSION OBTAINED FROM COGNIZANT STRUCTURES ENGINEER; DO NOT USE "V" REFERENCE TABULATED ON F/D.

NOTES CONTINUED NEXT COLUMN

...ED TO SUIT STOCK
...G THICKNESS
... AT ALL
...LY .5 MINIMUM
... & END CHANNELS

... MASS.

-111	-107	-105	-103	-101	-11	-7	-3	PART NUMBER	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
AR	AR	AR	AR	AR	AR	AR	AR		POTTING	DEVCON PLASTIC STEEL B		7	4
								-411	BLOCK	MAPLE WOOD 3	[illegible]		
								-409	CHANNEL	6061-T6 AL ALY EXTR	[illegible]	QQ-A-200/16	
2	2	2	2	2	2	2	2	-407	BLOCK	MAPLE WOOD 3	[illegible]		
2	2	2	2	2	2	2	2	-405	CHANNEL	6061-T6 AL ALY EXTR	[illegible]	QQ-A-200/16	
								-335	PANEL	M/F TT802024 -59	2		
								-331	PANEL	M/F TT802024 -31	2		
								-329		-27			
								-327		-21			
								-325		-17			
								-323	PANEL	M/F TT802024 -37	2		
								-319	PANEL	[illegible]	2		
								-317		[illegible]			
								-315		-19			
								-313		[illegible]			
								-311	PANEL	M/F TT802024 -61	2		
								-307	PANEL	M/F TT802024 -7	2		
								-303	PANEL	M/F TT802024 -3	2		
								-211	PANEL ASSY				
								-207	PANEL ASSY				
								-205					
								-203					
								-201	PANEL ASSY				
								-111	PANEL ASSY				
								-107	PANEL ASSY				
								-105					
								-103					
								-101	PANEL ASSY				
								-11	PANEL ASSY				
								-7	PANEL ASSY				
								-3	PANEL ASSY				

PARTS LIST

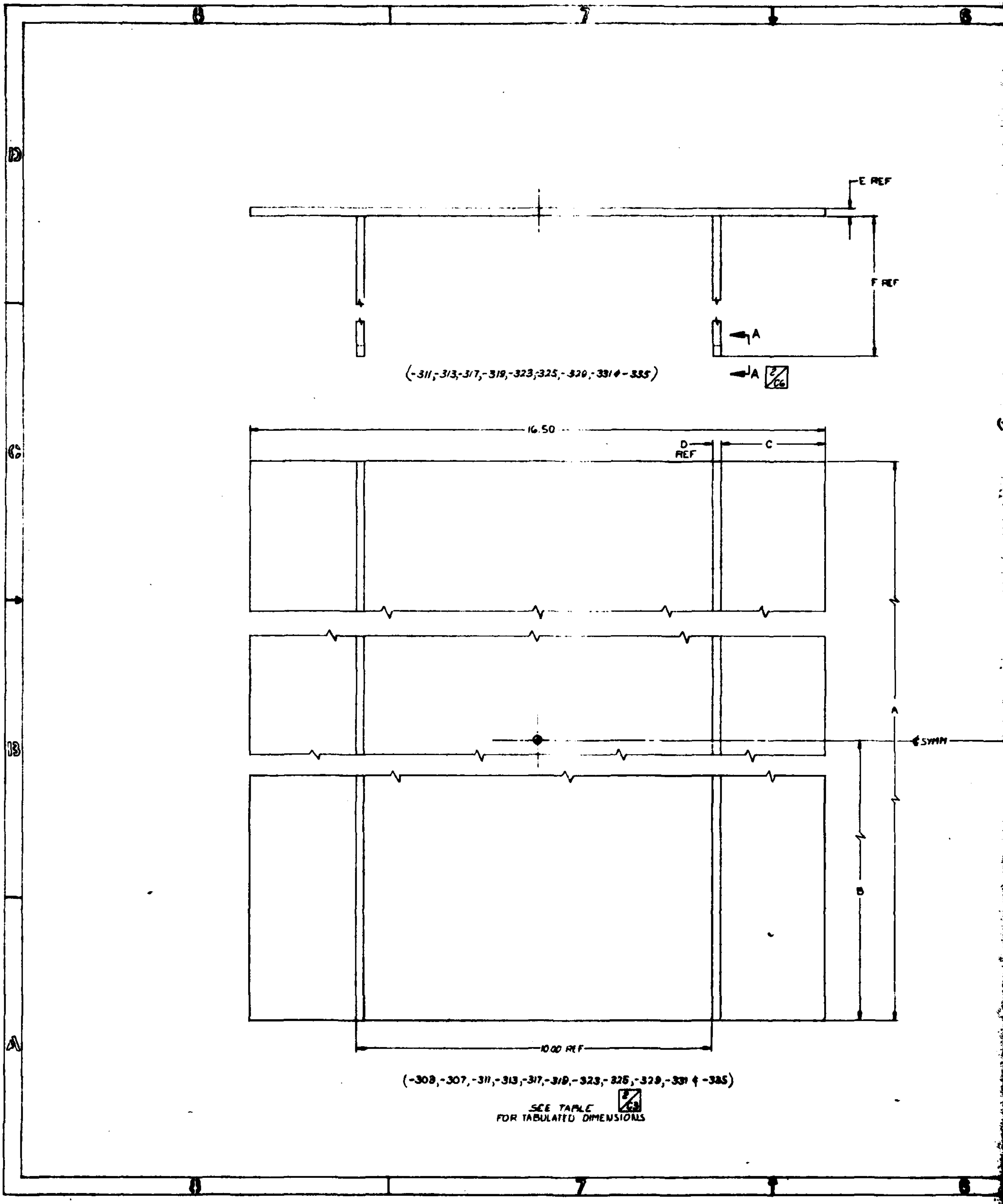
REVISION STATUS OF SHEETS	REV.	A	A
	SHEET	1	2

DOCUMENT RELEASE

TEST ARTICLE ASSY-
STIFFENED PANEL,
COMPRESSION BUCKLING TEST

J TT802023 A

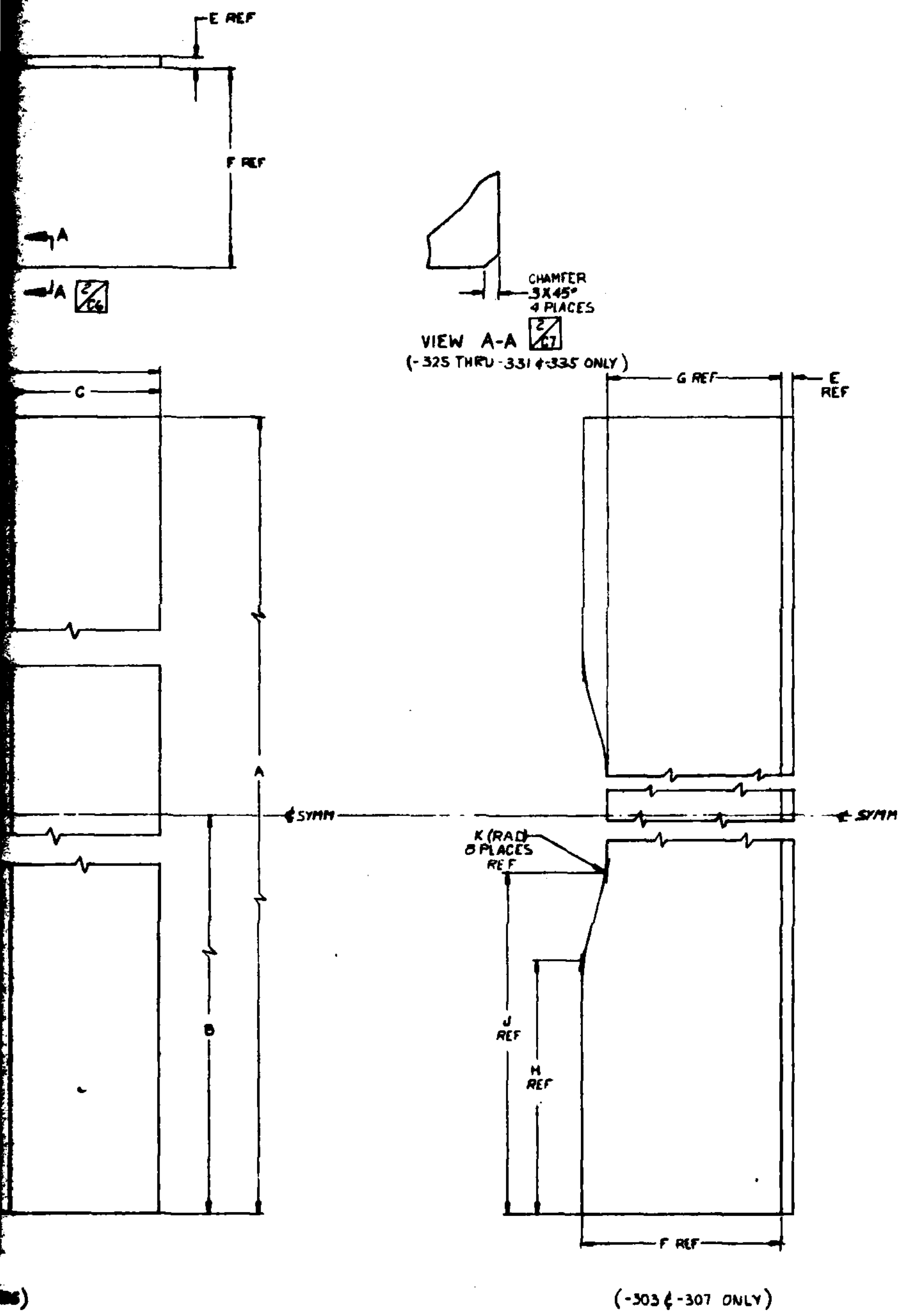
SHEET 1 OF 2



E REF
F REF
A
(-311,-313,-317,-319,-323,-325,-329,-331 & -335)
A
16.50
D REF
C
A
℄ SYMM
B
10.00 REF
(-309,-307,-311,-313,-317,-319,-323,-325,-329,-331 & -335)
SEE TABLE
FOR TABULATED DIMENSIONS

2

7 6 5 4



ITEM	A
-303	29
-307	29
-311	29
-313	
-315	
-317	
-319	29
-323	2
-325	2
-327	
-329	
-331	2
-335	2

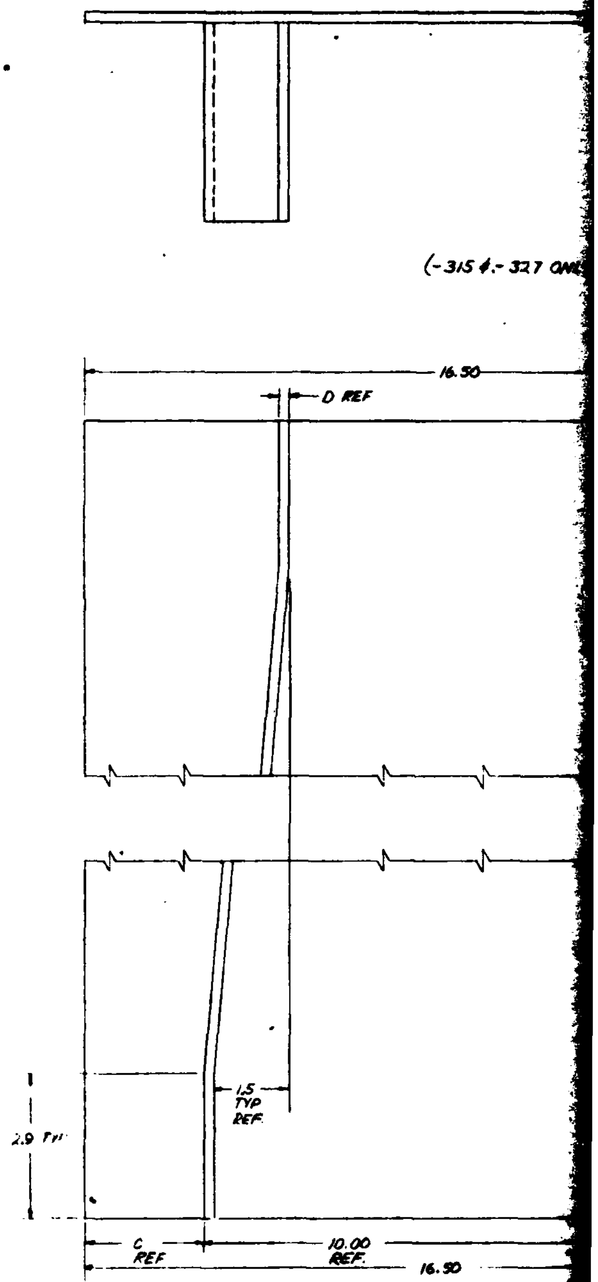
TT802023 A
SHT 2
FRAME 2 — FRAME 1

7 6 5 4

3

4	3	2

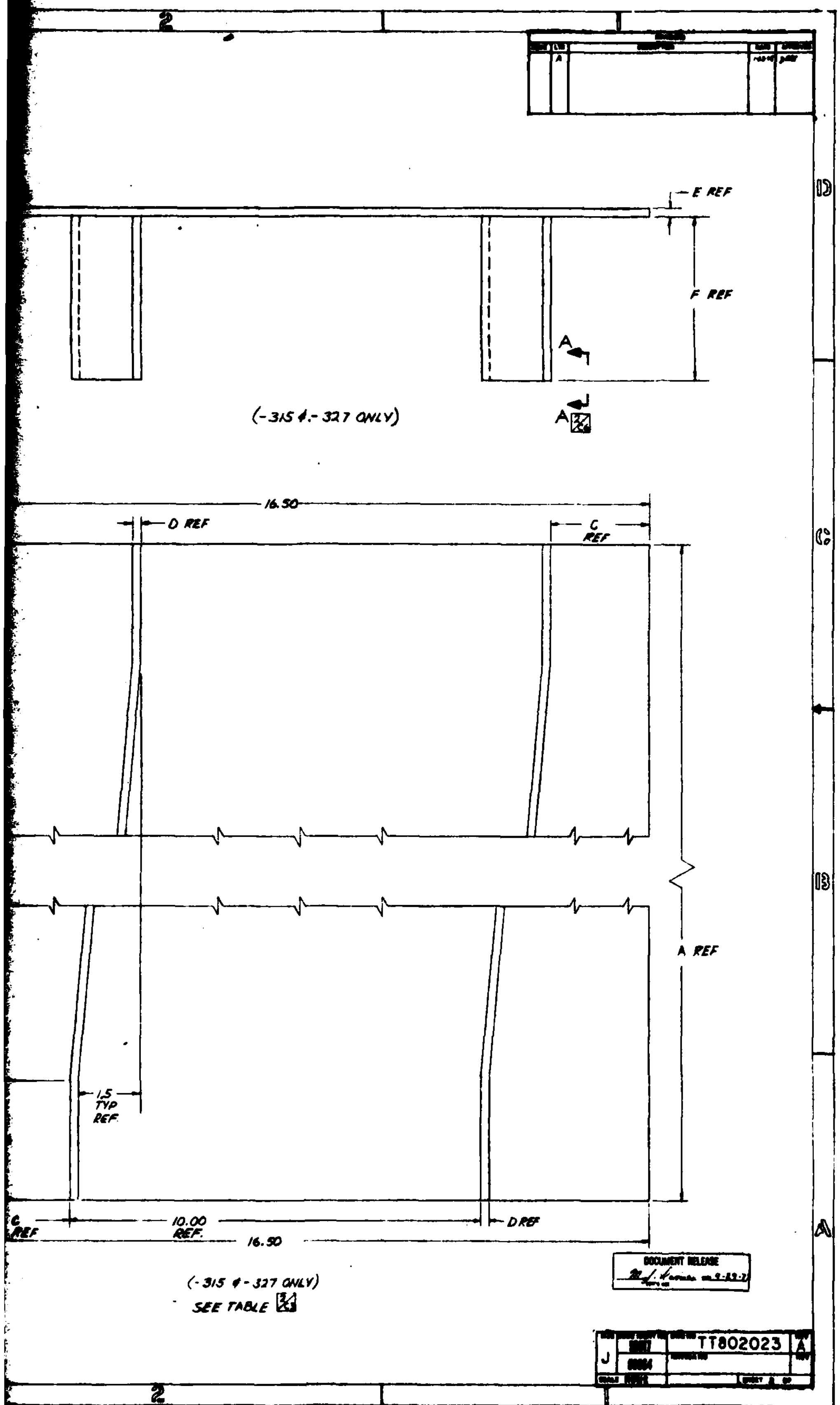
PANEL TRIM DIMENSIONS										
ITEM	A	B	C	D	E REF	F REF	G REF	H REF	J REF	K REF
-303	29.872	14.94	3.13	.250	.281	4.00	3.50	3.94	7.94	2.0
-307	29.872	14.94	3.13	.250	.281	4.00	3.50	3.94	7.94	2.0
-311	29.872	14.94	3.13	.250	.281	4.00				
-313			3.13		.200					
-315			2.38							
-317			3.13							
-319	29.872	14.94	3.13	.250	.200	4.00				
-323	29.872	14.94	3.13	.200	.200	4.00				
-325	29.662	14.83	3.06	.375	.344	5.25				
-327			2.31							
-329			3.06							
-331	29.662	14.83	3.06	.375	.344	5.25				
-335	29.662	14.83	3.06	.375	.344	5.25	—	—	—	—



(-315 & -327 ONLY)
SEE TABLE

4	3	2

4



E REF
F REF
(-315 & -327 ONLY)
16.50
D REF
C REF
A REF
1.5 TYP REF
C REF
10.00 REF
D REF
16.50
(-315 & -327 ONLY)
SEE TABLE
DOCUMENT RELEASE
TT802023
J
A

NOTES: CONTD

29 (DELETED)

30 PRIOR TO WELDING, LIGHTLY CONTA
ZONES INDICATED WITH KEROSENE T
IN MULTIPLE PASS WELDS, CONTAM
OR PASSES IN WHICH REPAIRS AR
MULTIPLE REPAIRS ARE SUPERWI
ONLY TO AFFECT THE INITIAL WELD

31. MATERIAL WHICH REQUIRES CHEM-MILL
REQUIRED THICKNESS SHALL BE
OVERSIZE IN ORDER TO PROVIDE
OF 1-INCH EDGE TRIM-BACK ON A
MILLING.

TABLE I

PANEL ASSY	A	B	C	D	E	PLATE THICK (REF)	STIFF THICK (REF)	STIFF HEIGHT (REF)
-1	0 TO $\frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.250	.313	$3\frac{3}{4}$
-5	—	—	—	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.281	.250	4
-7	—	—	—			.281	.250	4
-9	0 TO $\frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.250	.313	$3\frac{3}{4}$
-15	$\frac{1}{16}$ TO $\frac{1}{8}$	$0 \pm \frac{1}{16}$	$\frac{1}{16}$ TO $\frac{1}{8}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.200	250	4
-17	$\frac{1}{16}$ TO $\frac{1}{8}$	$0 \pm \frac{1}{16}$	$\frac{1}{8}$ TO $\frac{1}{4}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.344	.373	$5\frac{1}{4}$
-19	$0 \pm \frac{1}{16}$	$1\frac{1}{2} \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$\frac{1}{4} \pm \frac{1}{16}$	0 TO $\frac{1}{8}$	200	250	4
-21	$0 \pm \frac{1}{16}$	$1\frac{1}{2} \pm \frac{1}{16}$	0 TO $\frac{1}{8}$	$\frac{1}{4} \pm \frac{1}{16}$	0 TO $\frac{1}{8}$	.344	.375	$5\frac{1}{4}$
-25	$0 \pm \frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$\frac{1}{4} \pm \frac{1}{16}$	0 TO $\frac{1}{8}$	.200	.250	4
-27	$0 \pm \frac{1}{16}$		0 TO $\frac{1}{8}$	$\frac{1}{4} \pm \frac{1}{16}$	0 TO $\frac{1}{8}$	.344	.375	$5\frac{1}{4}$
-29	$0 \pm \frac{1}{16}$		0 TO $\frac{1}{16}$	$\frac{3}{8} \pm \frac{1}{16}$	0 TO $\frac{1}{4}$	.200	.250	4
-31	$0 \pm \frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{8}$	$\frac{3}{8} \pm \frac{1}{16}$	0 TO $\frac{1}{4}$	.344	.375	$5\frac{1}{4}$
-37	$0 \pm \frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$\frac{3}{8} \pm \frac{1}{16}$	0 TO $\frac{1}{4}$	.200	.250	4
-39	$0 \pm \frac{1}{16}$		0 TO $\frac{1}{8}$	$\frac{3}{8} \pm \frac{1}{16}$	0 TO $\frac{1}{4}$	.344	.375	$5\frac{1}{4}$
-41	$\frac{1}{16}$ TO $\frac{1}{8}$	$0 \pm \frac{1}{16}$	$\frac{1}{16}$ TO $\frac{1}{8}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.250	.313	$3\frac{3}{4}$
-51	$0 \pm \frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.250	.313	$3\frac{3}{4}$
-53	$0 \pm \frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.250	.313	$3\frac{3}{4}$
-57	$0 \pm \frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.250	.313	$3\frac{3}{4}$
-59						.250	.313	$3\frac{3}{4}$
-61						.281	.250	4
-63	$0 \pm \frac{1}{16}$	$0 \pm \frac{1}{16}$	0 TO $\frac{1}{16}$	$0 \pm \frac{1}{8}$	$0 \pm \frac{1}{8}$	.250	.313	$3\frac{3}{4}$

2-1 1

NOTES:

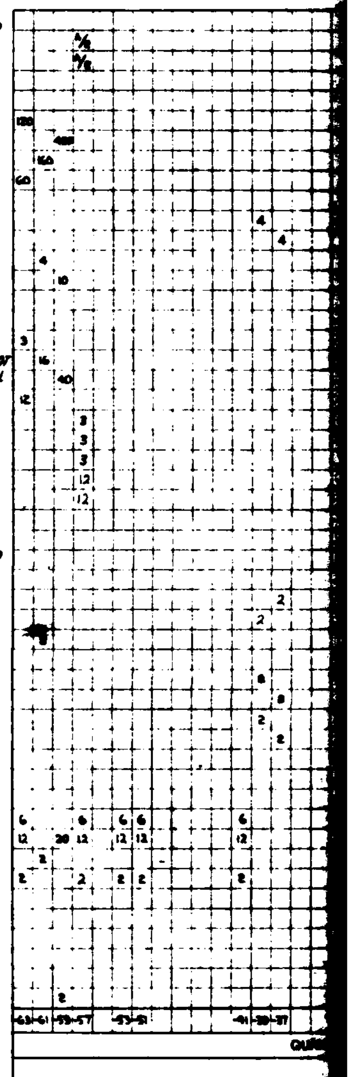
1. BREAK ALL SHARP EDGES
2. ALL FABRICATION PROCEDURES TO BE DOCUMENTED FOR ENGINEERING REFERENCE.
3. UNLESS OTHERWISE SPECIFIED, ALL FABRICATION, WELDING & INSPECTION TO BE PER NAVSEA 0900-LP-060-4010.
4. WELD SYMBOLS PER AWS-A-2.0.
5. ALL WELDING MUST BE PER PROCEDURES QUALIFIED FOR 3KSES PRODUCTION, EXCEPT AS NOTED.
6. WELD REPAIRS OF IMPERFECTIONS OTHER THAN THOSE SPECIFIED ARE NOT PERMITTED WITHOUT SPECIFIC STRUCTURES ENGINEERING APPROVAL.
7. COGNIZANT STRUCTURES ENGINEER TO WITNESS FIRST ARTICLE WELDING & FIRST ARTICLE SPECIFIED REPAIR WELDING.
8. AFTER ALL WELDING INCLUDING REPAIR WELDING OPERATIONS ARE COMPLETED, STRAIGHTENING (IF REQD) SHALL BE THE MINIMUM NECESSARY TO MEET SPECIFIED DRAWING TOLERANCES. ALL STRAIGHTENING PROCEDURES TO BE FULLY DOCUMENTED INCLUDING BEFORE AND AFTER CONDITIONS.
9. SURFACE INSPECTION CRITERIA FOR ALL WELDS TO BE PER NAVSEA 0900-LP-003-8000 (CLASS 3 MINIMUM) BASED ON 100% VISUAL & GROUP III LIQUID PENETRANT INSPECTION.
10. ALL INSPECTIONS TO BE FULLY DOCUMENTED INCLUDING PROCEDURES, GENERAL DESCRIPTIONS & LOCATIONS OF ACCEPTABLE IMPERFECTIONS & DETAILED NATURE, SIZES & LOCATIONS OF ALL IMPERFECTIONS EXCEEDING ACCEPTANCE STANDARDS.
11. PERMANENTLY IDENTIFY EACH ASSEMBLY IN APPROXIMATE LOCATION SHOWN USING 1/4 MIN HIGH CHARACTERS. IDENTIFICATION TO CONSIST OF LAST 3 DIGITS OF DRAWING NUMBER FOLLOWED BY ASSEMBLY DASH NUMBER, e.g. 024-015.
12. FINISHED PANEL SURFACE FLATNESS FOR EACH TEST SPECIMEN REGION SHALL NOT DEVIATE MORE THAN .125 TIR FROM A FLAT PLANE ESTABLISHED BY PLACING THE PANEL ON HEIGHT BLOCKS AT ALL FOUR NOTED POINTS LOCATED ON THE PANEL SURFACE OPPOSITE THE STIFFENERS USING HAND PRESSURE ONLY APPLIED AT ANY CORNER NECESSARY TO PRODUCE CONTACT. THE PORTIONS OF PANEL EXTENDING BEYOND THE AREA OF MEASUREMENT SHALL BE SUPPORTED TO SUSTAIN ANY OVERHANGING WEIGHT.
13. ALL PANEL ASSEMBLY AND WELDING SEQUENCING SHALL BE PERFORMED IN THE MANNER PLANNED FOR 3KSE PRODUCTION.
14. FINAL TRIM LINES FOR SPECIMENS TO BE DEFINED ON NOTED DRAWING.
15. MAKE WELD REPAIRS BY GRINDING OUT SEGMENTS OF WELD BEAD REQUIRED TO REMOVE DEFECTIVE WELD & REWELDING PER QUALIFIED REPAIR WELD PROCEDURES. DOCUMENTED VISUAL & DYE PENETRANT INSPECTIONS ARE REQUIRED BEFORE & AFTER REPAIR WELDING. USE GROUP III LIQUID PENETRANT ONLY.
16. PEEN SURFACES OF WELD BEADS OVER LENGTH INDICATED & SUFFICIENT WIDTH TO COVER HEAT AFFECTED ZONE ON BOTH SIDES. PEENING INTENSITY TO BE ALMEN 'A' .004-.008 ARC HEIGHT. METHOD OF PEENING (ROTARY FLAPPER OR SHOT) TO BE SPECIFIED BY STRUCTURES ENGINEERING. PEENING TO BE PERFORMED AFTER ALL WELDING, REPAIR WELDING & STRAIGHTENING OPERATIONS HAVE BEEN COMPLETED & INSPECTED.
17. WELD RUNOUT ALLOWANCE
18. CUTTING ALLOWANCE
19. WHERE A STIFFENER IS FILLET WELDED ACROSS A PLATE BUTT WELD, THE BUTT WELD SHALL FIRST BE SHAVED FLUSH FOR 1 INCH ON EACH SIDE OF THE FILLET WELD LOCATION.
20. 100% RADIOGRAPHIC INSPECTION OF ALL BUTT WELDS TO BE PERFORMED PER MIL-STD-271. ACCEPTANCE CRITERIA TO BE PER NAVSEA 0900-LP-003-9000 (CLASS 3 MINIMUM).
21. AFTER COMPLETING WELD REPAIR REQUIREMENTS PER 15, SIMULATE REPEATED WELD REPAIRS AS INDICATED ON F/D. BASIC PROCEDURES TO BE SAME AS 15.
22. AFTER COMPLETION OF PANEL FABRICATION INCLUDING INSPECTION ACCEPTANCE, SUBMIT PANEL TO COGNIZANT STRUCTURES ENGINEER. STRAIGHTEN DISTORTED PANEL RETURNED BY STRUCTURES ENGINEER TO TOLERANCES SPECIFIED ON F/D. STRAIGHTENING METHODS PROPOSED FOR 3KSES PRODUCTION SHALL BE USED. ALL STRAIGHTENING OPERATIONS TO BE FULLY DOCUMENTED INCLUDING BEFORE AND AFTER CONDITIONS.
23. TO BE SUPPLIED BY COGNIZANT STRUCTURES ENGINEER.
24. SHAVE WELD/WELD REPAIR BEAD REINFORCEMENTS FLUSH TO $\frac{1}{64}$ ABOVE BASE METAL SURFACES WHERE DOUBLERS WILL BE INSTALLED. FLUSH AREA TO EXTEND 1/8 TO 1/4 BEYOND EDGE OF DOUBLER.
25. PREPARE DOUBLERS AND PANELS FOR BONDING PER ROHR MPD 02004. WITHIN 1 HOUR AFTER CLEANING APPLY THIN COATING OF PRIMER TO EACH BOND SURFACE AND DRY 1 HOUR AT 75°F. APPLY PRIMER AS RECEIVED TO ONLY WET THE BOND SURFACES.
26. LAMINATE BOND PRIMED DOUBLERS TO PRIMED SPECIMEN PER ADHESIVE MANUFACTURERS INSTRUCTIONS. MAXIMUM BOND LINE THICKNESS NOT TO EXCEED 1/32.
27. MANUFACTURED BY HUCK MFG CO; LOS ANGELES, CALIF.
28. SHAVE WELD FLUSH TO $\frac{1}{32}$ ABOVE BASE METAL.

NOTES: CONTD

29. (DELETED)

30. PRIOR TO WELDING, LIGHTLY CONTAMINATE WELD REPAIR ZONES INDICATED WITH KEROSENE TO CREATE WELD DEFECTS. IN MULTIPLE PASS WELDS, CONTAMINATE ONLY THE PASS OR PASSES IN WHICH REPAIRS ARE SPECIFIED. WHERE MULTIPLE REPAIRS ARE SUPERIMPOSED CONTAMINATE ONLY TO AFFECT THE INITIAL WELD MADE.

31. MATERIAL WHICH REQUIRES CHEM-MILLING TO ACHIEVE THE REQUIRED THICKNESS SHALL BE ORDED SUFFICIENTLY OVERSIZE IN ORDER TO PROVIDE A REQURED MINIMUM OF 1-INCH EDGE TRIM-BACK ON ALL EDGES AFTER CHEM-MILLING.



TT802024 A 1

3 1

PART NUMBER	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC.	PROCESS
	PRIMER				
	ADHESIVE				
OSR-10-F	RIVET, BLIND				
OSR-10-K					
OSR-10-J					
OSR-10-G	RIVET, BLIND.				
-179	STIFFENER	AL ALY 5456-H116/H117	.375 x 5½ x 24	QQ-A-250/20	
-177			.250 x 4 x 24		
-175			.250 x 4 x 24		
-173	STIFFENER	AL ALY 5456-H116/H117	.313 x 3½ x 24	QQ-A-250/20	
-167	DOUBLER	AL ALY 5456-H116/H117	.160 x 8½ x 11½	QQ-A-250/20	
-165			.250 x 3 x 12		
-163		AL ALY 5456-H116/H117	.250 x 3½ x 12		
-161		AL ALY 5456-H323	.080 x 3½ x 8		
-159			.032 x 6 x 8½		
-157			x 4 x 6½		
-155			x 2 x 8½		
-153			x 2 x 3½		
-151	DOUBLER	AL ALY 5456-H323	.032 x 3½ x 4	QQ-A-250/20	
-141	HEADER	AL ALY 5456-H116/H117	.250 x 8 x 8½	QQ-A-250/20	
-139	HEADER		.375 x 5½ x 9½		
-137	STIFFENER	AL ALY 5456-H116/H117	.250 x 4 x 15	QQ-A-250/20	
-133	STIFFENER	AL ALY 5456-H116/H117	.375 x 5½ x 6	QQ-A-250/20	
-131	STIFFENER		.250 x 4 x 6		
-129	PLATE		.344 x 18 x 40		
-127	PLATE		.200 x 18 x 40		
-125	STIFFENER		.375 x 3½ x 15		
-123			.250 x 6 x 15		
-121			.250 x 4 x 36		
-119			.313 x 3½ x 20		
-117	STIFFENER		.313 x 3½ x 15		
-115	PLATE		.281 x 27 x 47		
-113			.250 x 27 x 60		
-111			.250 x 27 x 47		
-109			.344 x 27 x 47		
-107			.200 x 27 x 47		
-105	PLATE	AL ALY 5456-H116/H117	.281 x 36 x 46	QQ-A-250/20	
-101	PLATE	AL ALY 5456-H116/H117	.250 x 27 x 110	QQ-A-250/20	

QUANTITY REQUIRED

PARTS LIST

4

	A	INCORPORATED ECR T00050		

	MATERIAL SIZE	MATERIAL SPEC.	PROCESS
	.325 × 5½ × 24	QQ-A-250/20	
	.250 × 4 × 24		
	.250 × 4 × 24		
	.313 × 3½ × 24	QQ-A-250/20	
	.100 × 8½ × 11½	QQ-A-250/20	
	.250 × 3 × 12		
	.250 × 3½ × 12		
	.050 × 3½ × 8		
	.032 × 6 × 8½		
	× 4 × 8½		
	× 2 × 8½		
	× 2 × 3½		
	.032 × 3½ × 4	QQ-A-250/20	
	.250 × 8 × 8½	QQ-A-250/20	
	.375 × 5½ × 9½		
	.250 × 4 × 15	QQ-A-250/20	
	.375 × 5½ × 6	QQ-A-250/20	
	.250 × 4 × 6		
	.344 × 18 × 40		
	.200 × 18 × 40		
	.325 × 5½ × 15		
	.250 × 6 × 15		
	.250 × 4 × 36		
	.313 × 3½ × 28		
	.313 × 3½ × 15		
	.281 × 27 × 47		
	.250 × 27 × 60		
	.250 × 27 × 47		
	.344 × 27 × 47		
	.200 × 27 × 47		
	.281 × 36 × 48	QQ-A-250/20	
	.250 × 27 × 110	QQ-A-250/20	

PART NUMBER	SHT / ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC.	PROCESS
-63	5 /	PANEL ASSY				
-61	4 /					
-59	4 /					
-57	4 /	PANEL ASSY				
	4 /					
-53	3 /	PANEL ASSY				
-51	3 /	PANEL ASSY				
-41	3 /	PANEL ASSY				
-39	3 /					
-37	3 /	PANEL ASSY				
-31	3 /	PANEL ASSY				
-29	3 /					
-27	3 /					
-25	3 /	PANEL ASSY				
-21	2 /	PANEL ASSY				
-19	2 /					
-17	2 /					
-15	2 /	PANEL ASSY				
-9	2 /	PANEL ASSY				
-7	2 /					
-5	2 /	PANEL ASSY				
-1	2 /	PANEL ASSY				

PARTS LIST

REVISION STATUS OF SHEETS	REV	A	A	A	A	A
	SHEET	1	2	3	4	5

CONTRACT NO

DRAWN M. CALKINS

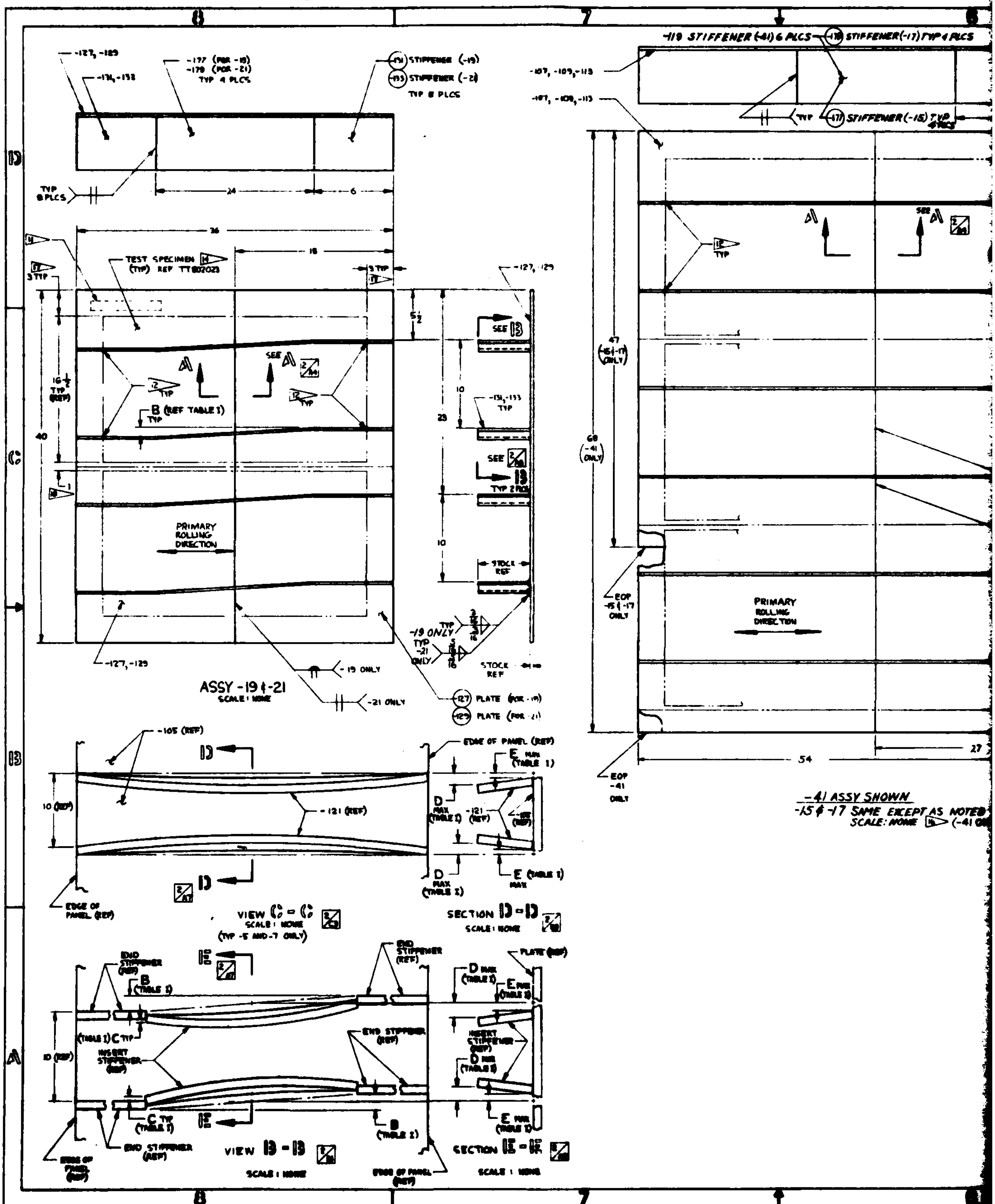
FABRICATION ASSY-
FLATBAR STIFFENED PANELS,
STRUCTURAL TEST

SIZE J

DWG NO TT802024

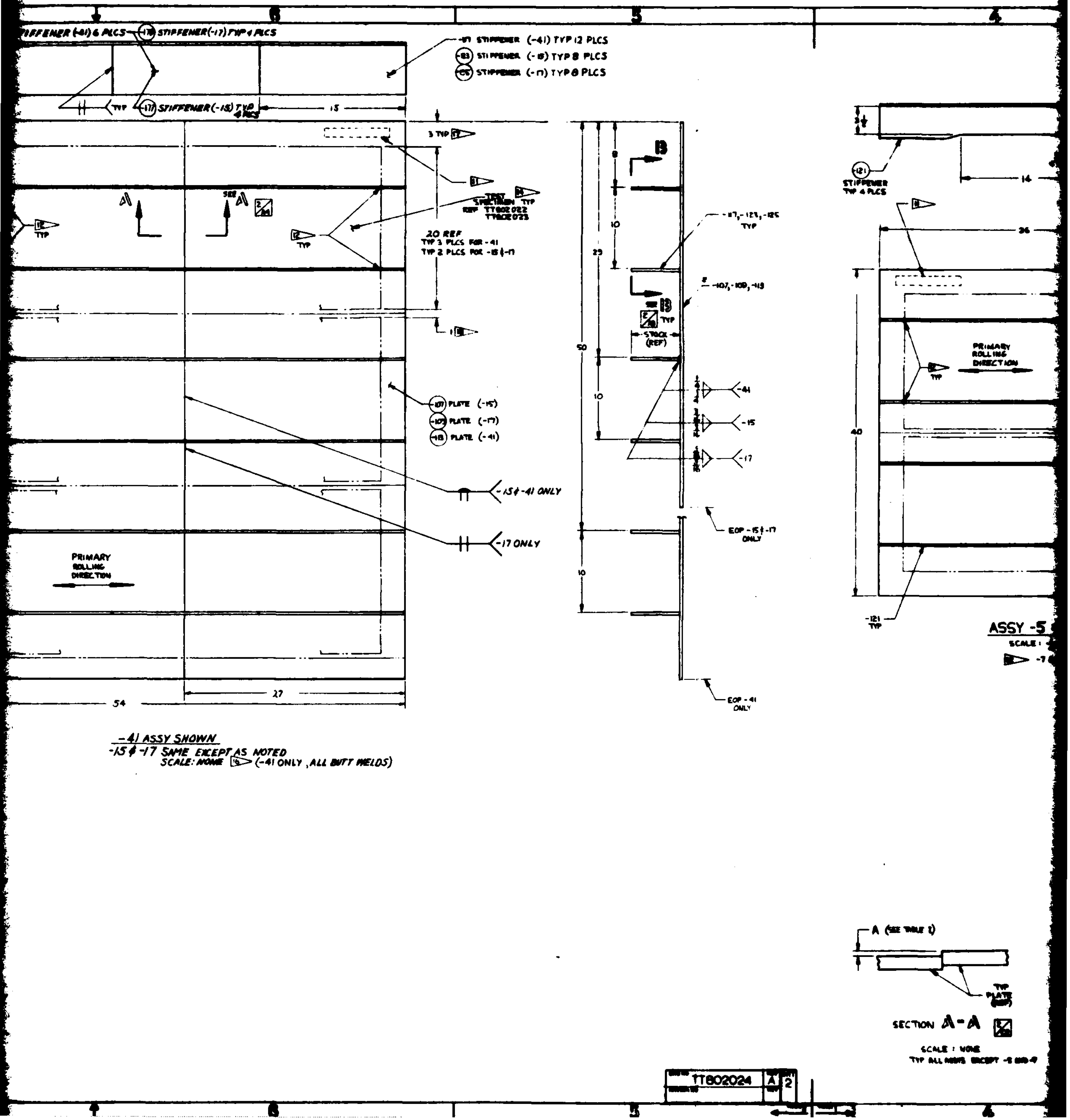
REV A

SHEET 1 OF 5

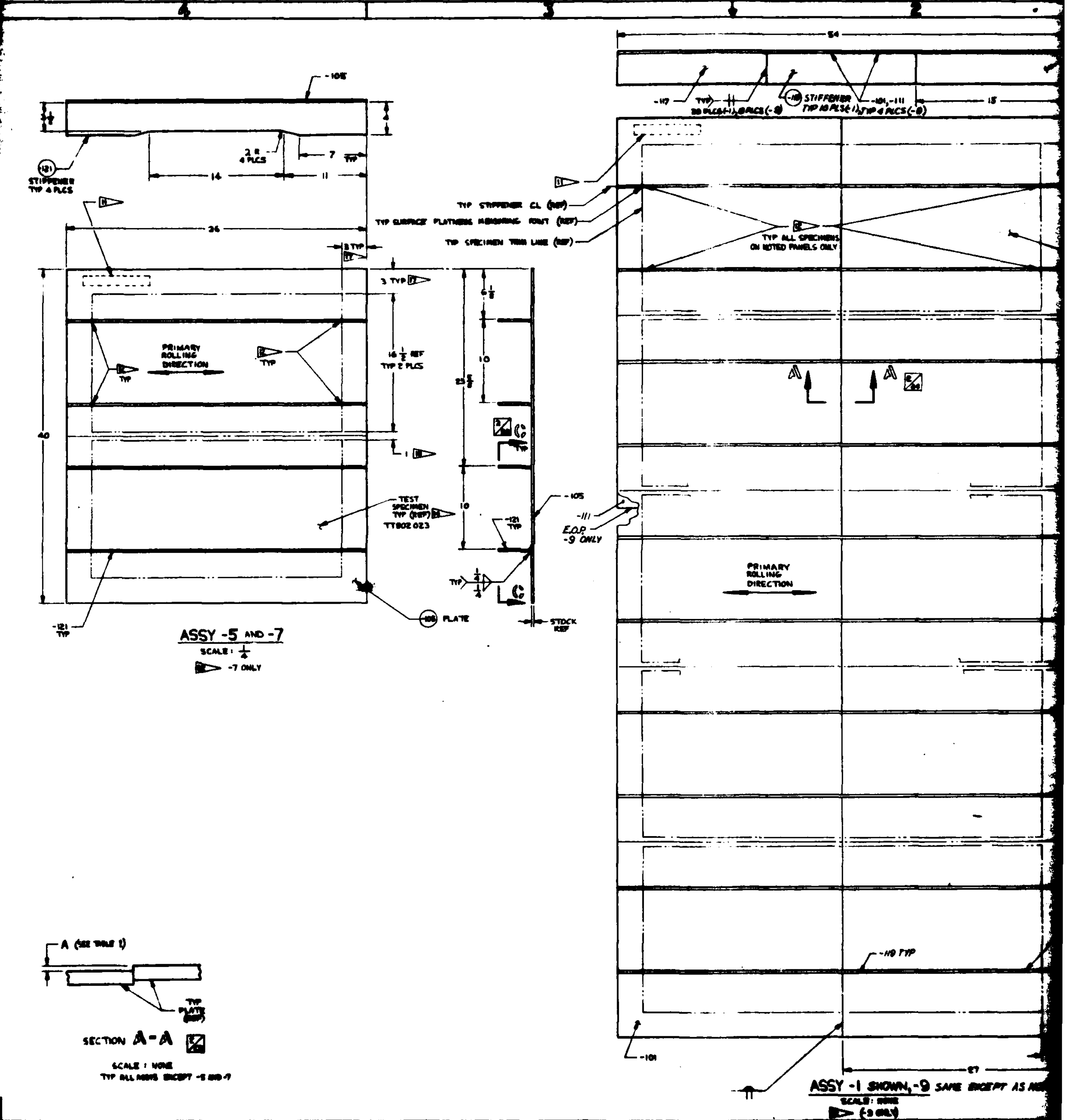


ASSY -19 & -21
SCALE: NONE
-41 ASSY SHOWN
-15 & -17 SAME EXCEPT AS NOTED
SCALE: NONE
PRIMARY ROLLING DIRECTION
TEST SPECIMEN (TYP) REF TT802023
-127, -129 PLATE (FOR -19)
-129 PLATE (FOR -21)
-119 STIFFENER (-41) 6 PLCS
STIFFENER (-17) TYP 4 PLCS
STIFFENER (-15) TYP
VIEW C - C
SCALE: NONE
(TYP -5 AND -7 ONLY)
SECTION D - D
SCALE: NONE
VIEW B - B
SCALE: NONE
SECTION E - E
SCALE: NONE
EDGE OF PANEL (REF)
END STIFFENER (REF)
INSERT STIFFENER (REF)

2 1


STIFFENER (-41) 6 PLCS
STIFFENER (-17) TYP 4 PLCS
STIFFENER (-15) TYP 4 PLCS
-111 STIFFENER (-41) TYP 12 PLCS
-123 STIFFENER (-15) TYP 8 PLCS
-125 STIFFENER (-17) TYP 8 PLCS
TEST SPECIMEN TYP REF TT802022 TT802023
20 REF
TYP 3 PLCS FOR -41
TYP 2 PLCS FOR -15 & -17
PLATE (-15)
PLATE (-17)
PLATE (-41)
-15 & -41 ONLY
-17 ONLY
PRIMARY ROLLING DIRECTION
-111, -123, -125 TYP
-107, -109, -113
STOCK (REF)
EOP - 15 & -17 ONLY
EOP - 41 ONLY
STIFFENER TYP 4 PLCS
-121 TYP
ASSY -5
-41 ASSY SHOWN
-15 & -17 SAME EXCEPT AS NOTED
SCALE: NONE (-41 ONLY, ALL BUTT WELDS)
A (SEE TABLE 1)
TYP PLATE
SECTION A-A
SCALE: NONE
TT802024
A 2

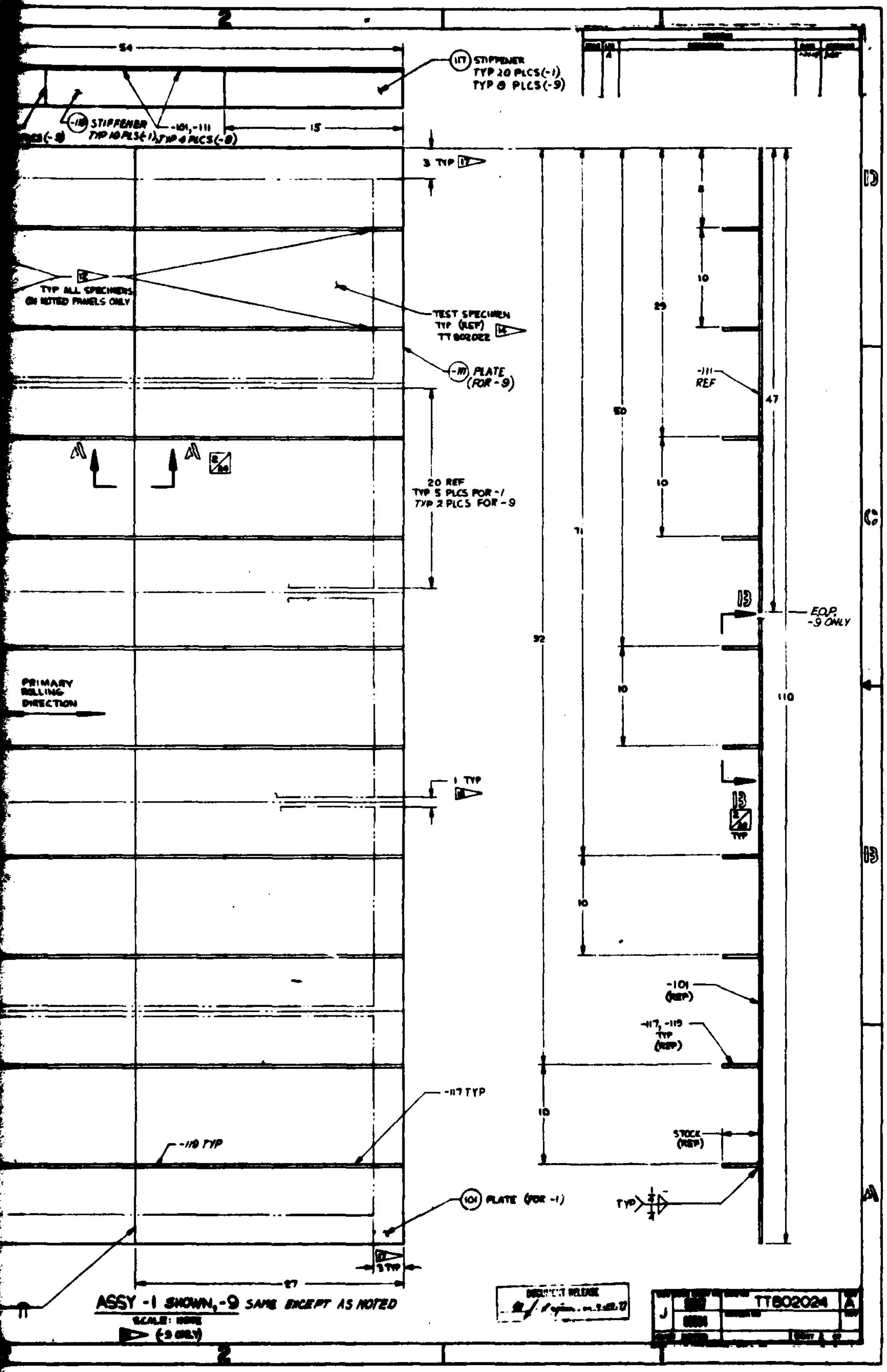
3



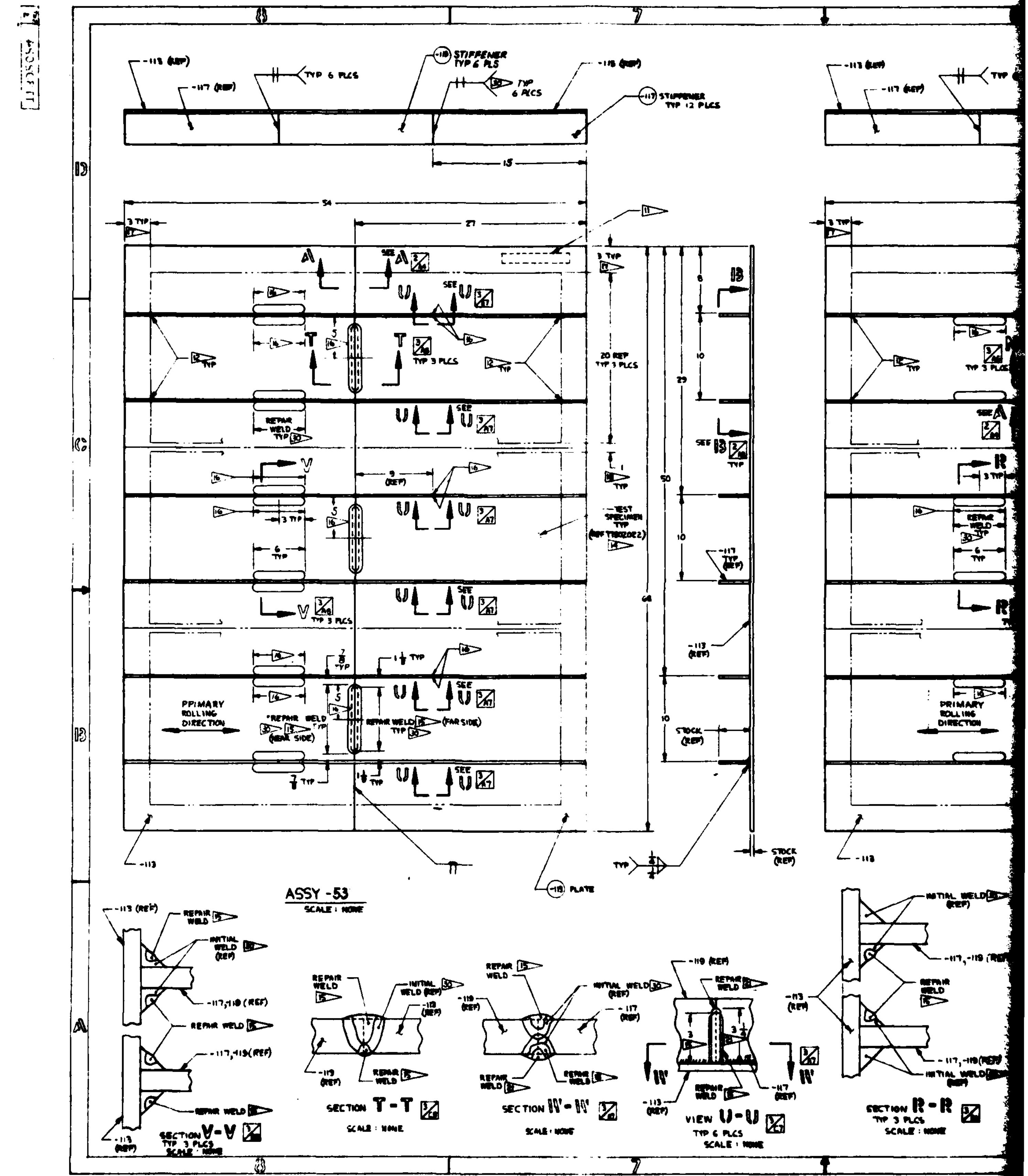
-105
STIFFENER TYP 4 PLCS
2 R 4 PLCS
14
11
7 TYP
26
3 TYP
PRIMARY ROLLING DIRECTION
TYP
16 1/2 REF TYP 2 PLCS
40
1
25 5/8
10
6 1/8
TEST SPECIMEN TYP (REF)
TT802023
-121 TYP
-105
-106 PLATE
STOCK REF
ASSY -5 AND -7
SCALE: 1/4
-7 ONLY
TYP STIFFENER CL (REF)
TYP SURFACE FLATNESS MEASURING POINT (REF)
TYP SPECIMEN TRIM LINE (REF)
TYP ALL SPECIMENS ON NOTED PANELS ONLY
54
15
-117
STIFFENER TYP 10 PLCS(-1), TYP 4 PLCS(-9)
-101, -111
-111
E.O.P. -9 ONLY
PRIMARY ROLLING DIRECTION
-119 TYP
-101
27
ASSY -1 SHOWN, -9 SAME EXCEPT AS NOTED
SCALE: NONE
(-9 ONLY)
A (SEE TABLE 1)
TYP PLATE (REF)
SECTION A-A
SCALE: NONE
TYP ALL ASSYS EXCEPT -5 AND -7

1

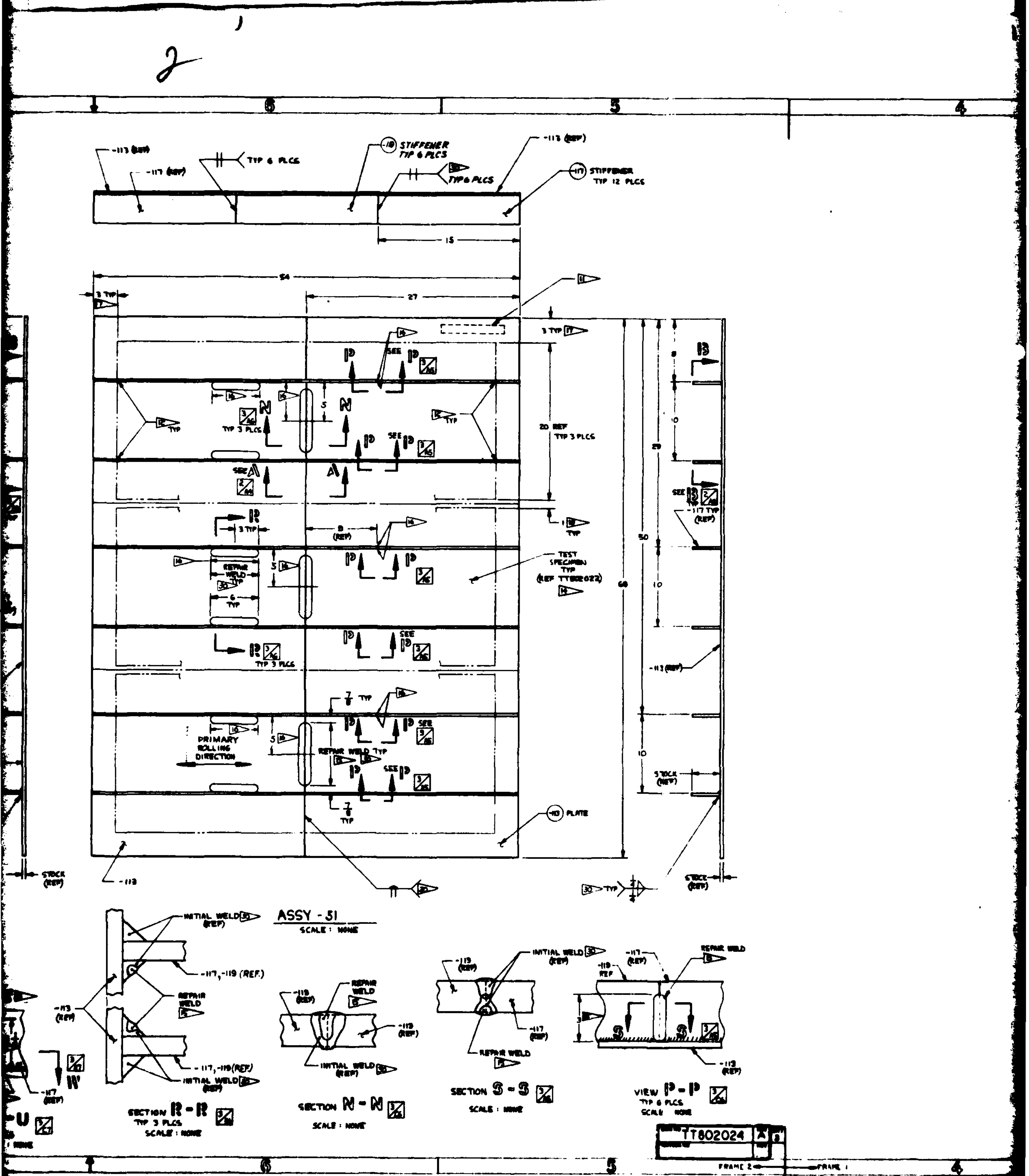
4



117 STIFFENER TYP 20 PLCS(-1) TYP 8 PLCS(-9)
-118 STIFFENER TYP 10 PLCS(-1) TYP 4 PLCS(-9)
-101, -111
54
15
3 TYP
TYP ALL SPECIMENS, ON NOTED PANELS ONLY
TEST SPECIMEN TYP (REF) TT802022
-111 PLATE (FOR -9)
20 REF TYP 5 PLCS FOR -1 TYP 2 PLCS FOR -9
PRIMARY ROLLING DIRECTION
1 TYP
-117 TYP
-119 TYP
101 PLATE (FOR -1)
27
3 TYP
-111 REF
EOP -9 ONLY
-101 (REF)
-117, -119 TYP (REF)
STOCK (REF)
TYP
8
10
29
50
71
92
47
110
D
C
B
A
ASSY -1 SHOWN, -9 SAME EXCEPT AS NOTED
SCALE: NONE
(-9 ONLY)
DOCUMENT RELEASE
J
TT802024
A

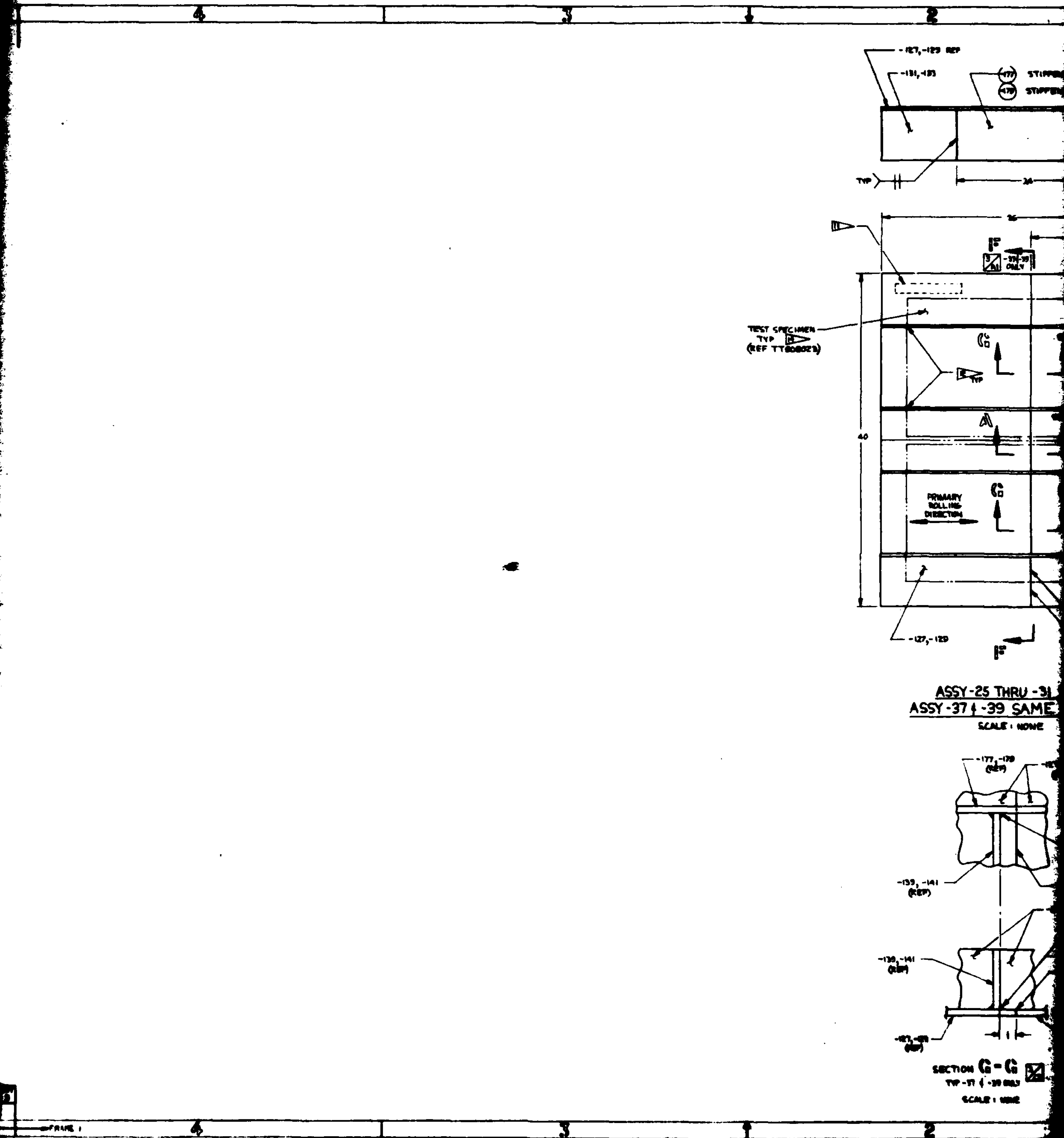


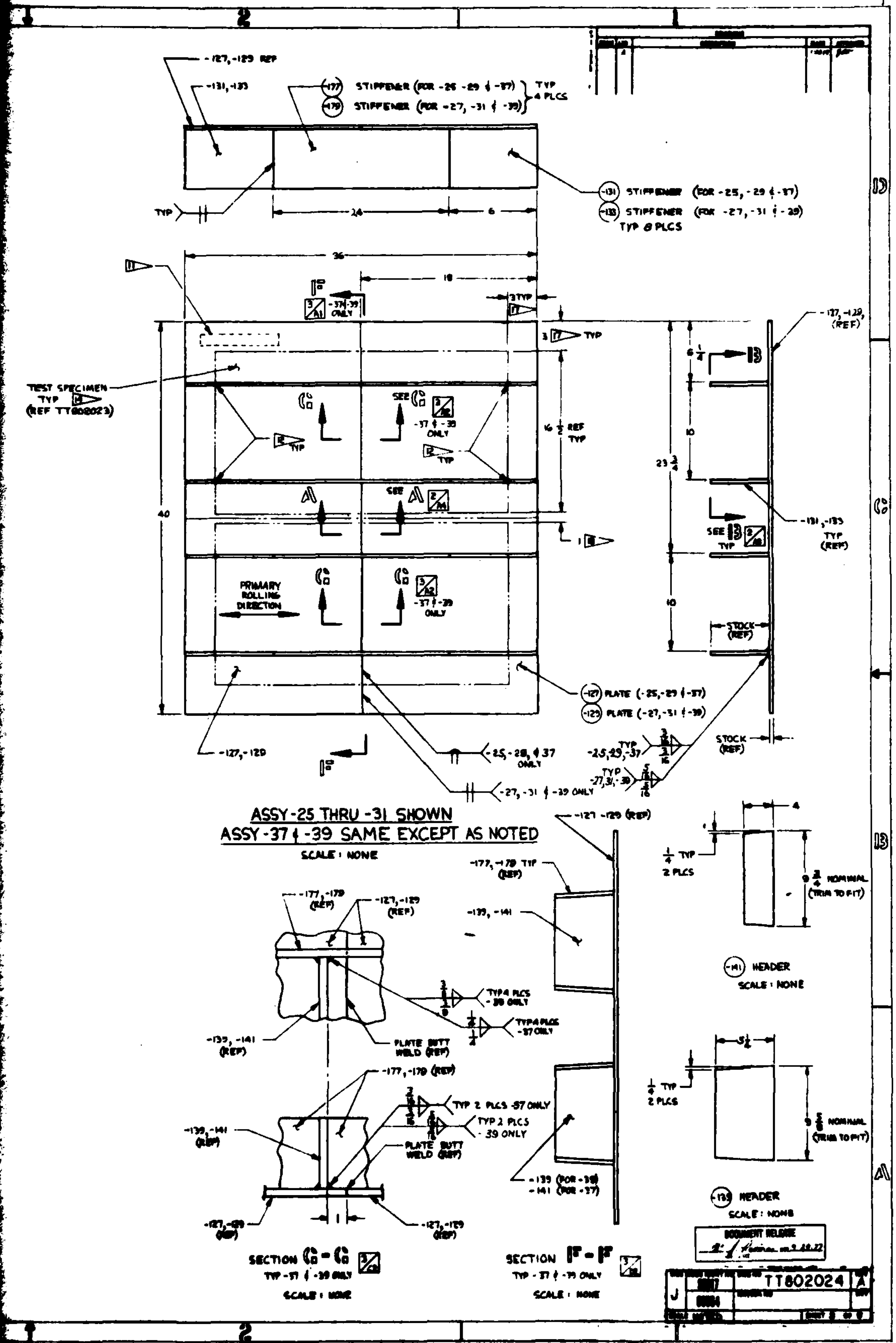
ASSY -53
SCALE : NONE
PRIMARY ROLLING DIRECTION
STIFFENER TYP 6 PLS
STIFFENER TYP 12 PLCS
TEST SPECIMEN TYP
PLATE
SECTION V-V
TYP 3 PLCS
SCALE : NONE
SECTION T-T
SCALE : NONE
SECTION W-W
SCALE : NONE
VIEW U-U
TYP 6 PLCS
SCALE : NONE
SECTION R-R
TYP 3 PLCS
SCALE : NONE
REPAIR WELD
INITIAL WELD (REF)



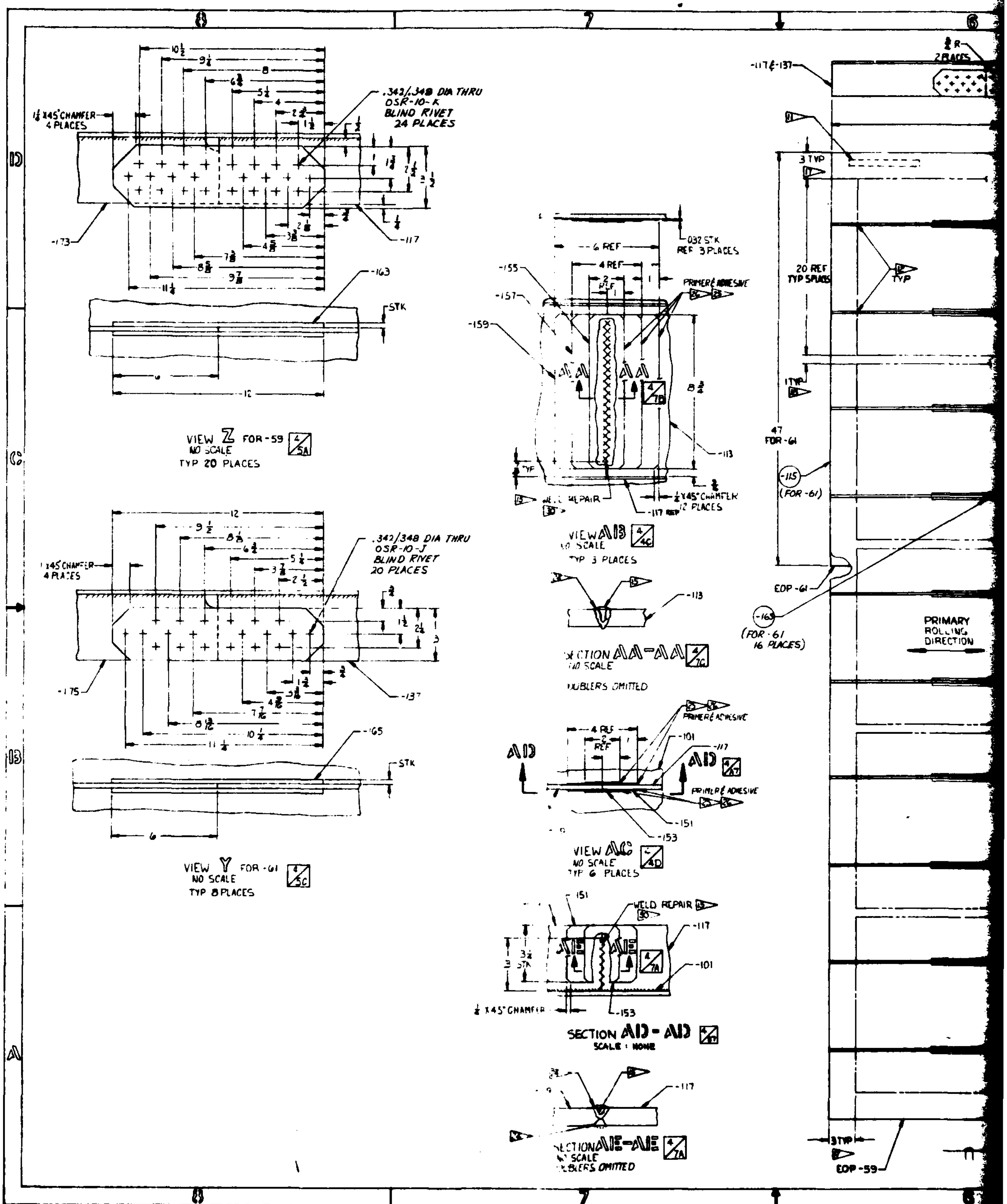
2
STIFFENER TYP 6 PLCS
STIFFENER TYP 12 PLCS
-113 (REF)
-117 (REF)
TYP 6 PLCS
54
27
15
PRIMARY ROLLING DIRECTION
REPAIR WELD TYP
TEST SPECIMEN TYP (REF TT802022)
20 REF TYP 3 PLCS
PLATE
STOCK (REF)
ASSY - 51
SCALE : NONE
INITIAL WELD (REF)
REPAIR WELD
-117, -119 (REF.)
SECTION R - R
TYP 3 PLCS
SCALE : NONE
SECTION N - N
SCALE : NONE
SECTION S - S
SCALE : NONE
VIEW P - P
TYP 6 PLCS
SCALE : NONE
TT802024
FRAME 2
FRAME 1
7
6
5
4

3

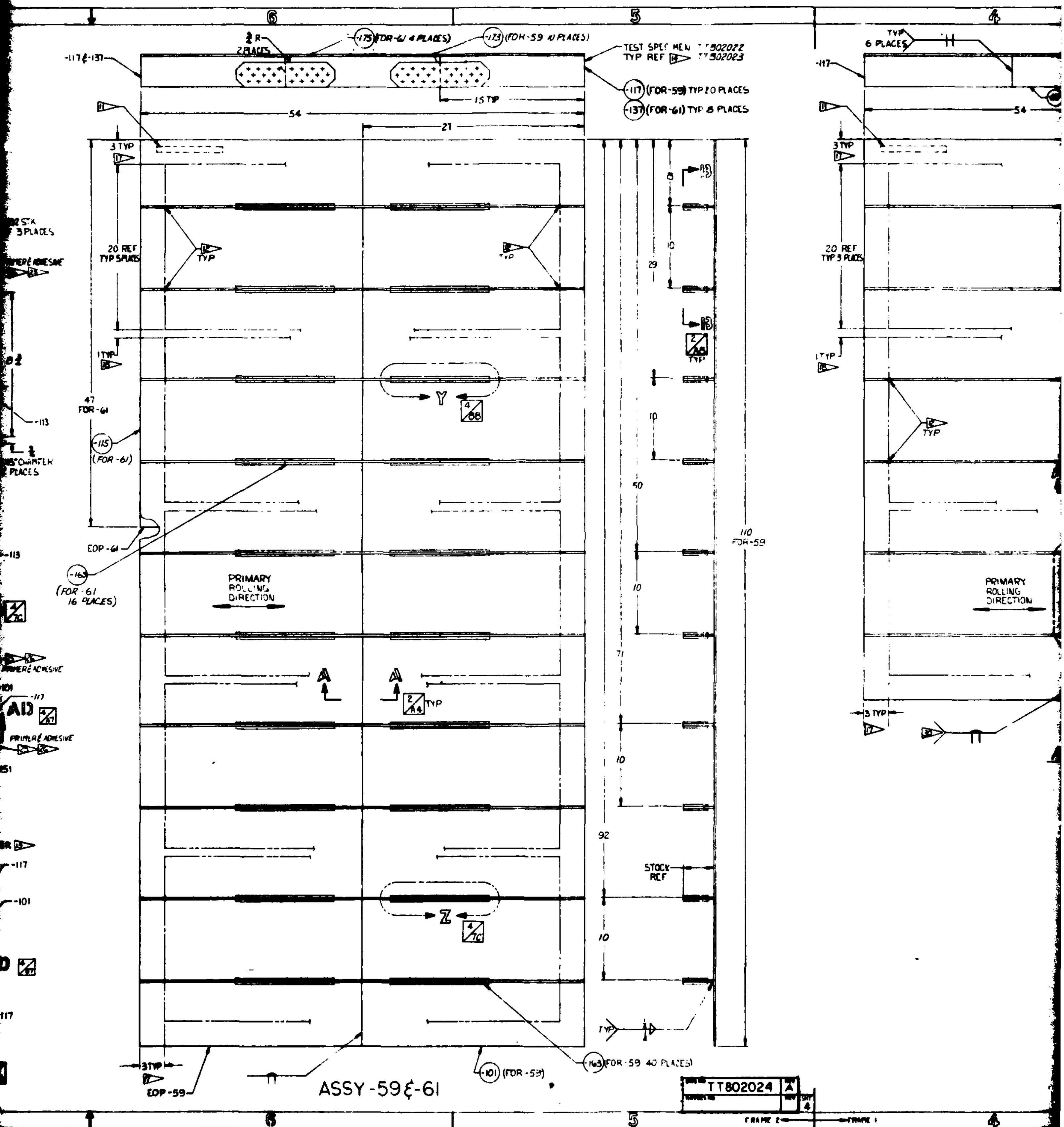

4
3
2
-127, -129 REF
-131, -133
TYP
TEST SPECIMEN
TYP
(REF TT808023)
PRIMARY
ROLLING
DIRECTION
40
-127, -129
ASSY-25 THRU -31
ASSY-37 & -39 SAME
SCALE: NONE
-177, -179
(REF)
-139, -141
(REF)
-139, -141
(REF)
SECTION G-G
SCALE: NONE
FRAME 1



STIFFENER (FOR -25 -29 & -37)
STIFFENER (FOR -27, -31 & -39) TYP 4 PLCS
-127, -129 REF
-131, -133
STIFFENER (FOR -25, -29 & -37)
STIFFENER (FOR -27, -31 & -39) TYP 8 PLCS
TEST SPECIMEN TYP (REF TT802023)
PRIMARY ROLLING DIRECTION
PLATE (-25, -29 & -37)
PLATE (-27, -31 & -39)
-25, -29, & 37 ONLY
-27, -31 & -39 ONLY
STOCK (REF)
ASSY -25 THRU -31 SHOWN
ASSY -37 & -39 SAME EXCEPT AS NOTED
SCALE: NONE
PLATE BUTT WELD (REF)
TYP 4 PLCS -39 ONLY
TYP 4 PLCS -37 ONLY
TYP 2 PLCS -37 ONLY
TYP 2 PLCS -39 ONLY
-139 (FOR -39)
-141 (FOR -37)
NOMINAL (TRIM TO FIT)
-141 HEADER
SCALE: NONE
-139 HEADER
SCALE: NONE
SECTION G - G
TYP -37 & -39 ONLY
SCALE: NONE
SECTION F - F
TYP -37 & -39 ONLY
SCALE: NONE
DOCUMENT RELEASE
TT802024 A

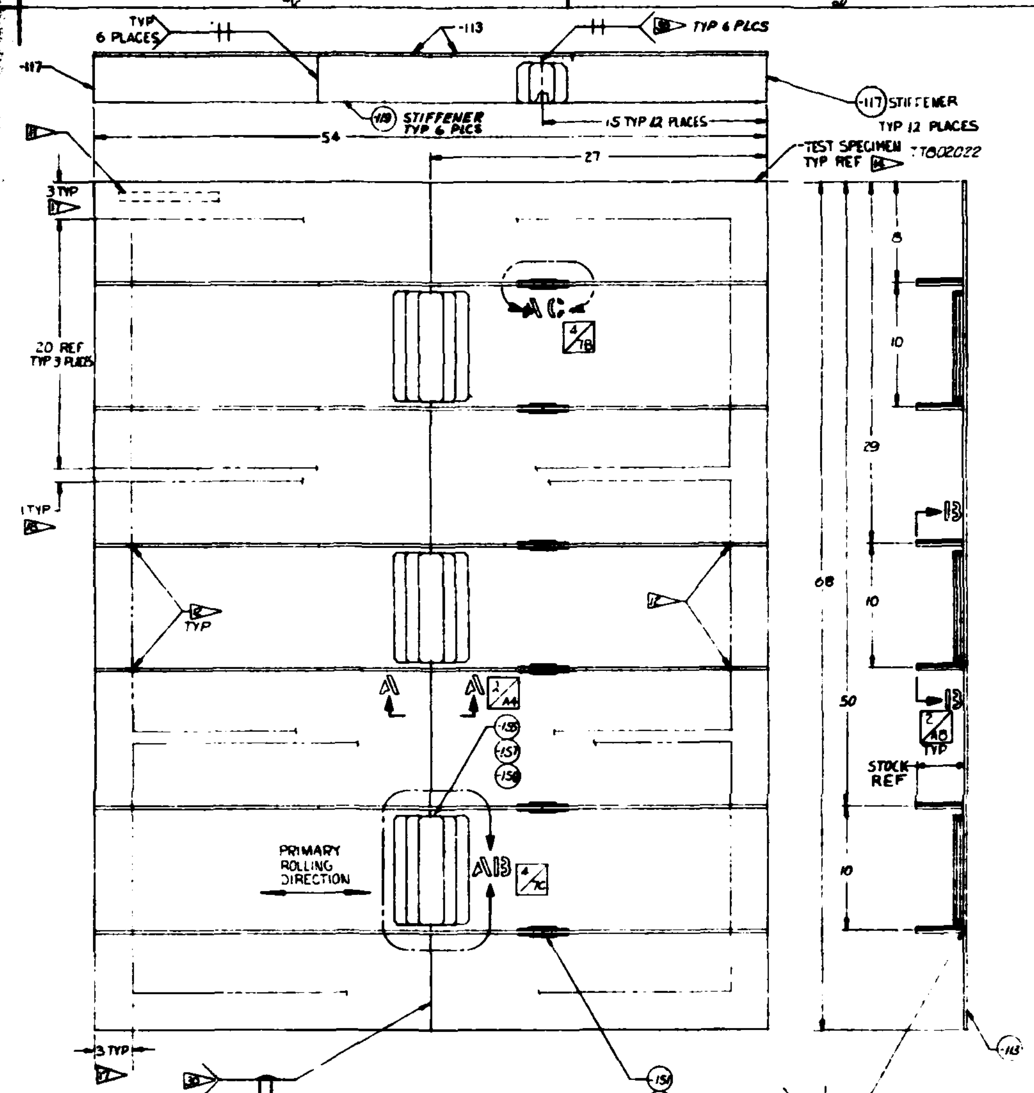

.342/.348 DIA THRU
OSR-10-K
BLIND RIVET
24 PLACES
1 1/2 X45° CHAMFER
4 PLACES
-173
-117
-163
STK
VIEW Z FOR -59
NO SCALE
TYP 20 PLACES
.342/.348 DIA THRU
OSR-10-J
BLIND RIVET
20 PLACES
1 X45° CHAMFER
4 PLACES
-175
-137
-165
VIEW Y FOR -61
NO SCALE
TYP 8 PLACES
.032 STK
REF 3 PLACES
6 REF
4 REF
PRIMER & ADHESIVE
-155
-157
-159
-113
WELD REPAIR
-117 REF
1/4 X45° CHAMFER
12 PLACES
VIEW AB
NO SCALE
TYP 3 PLACES
SECTION AA-AA
NO SCALE
DOUBLERS OMITTED
-101
-151
-153
VIEW AC
NO SCALE
TYP 6 PLACES
SECTION AD-AD
SCALE: NONE
1/4 X45° CHAMFER
SECTION AE-AE
NO SCALE
DOUBLERS OMITTED
-117 & -137
3/8 R
2 PLACES
3 TYP
20 REF
TYP SPLICES
TYP
47
FOR -61
-115
(FOR -61)
EOP -61
-165
(FOR -61
16 PLACES)
PRIMARY
ROLLING
DIRECTION
EOP -59

2



6
5
4
(-175) (FOR -61 4 PLACES)
(-173) (FOR -59 10 PLACES)
TEST SPECIMEN TT802022
TYP REF TT802023
(-117) (FOR -59) TYP 20 PLACES
(-137) (FOR -61) TYP 8 PLACES
-117 & -137
-117
TYP 6 PLACES
54
21
15 TYP
3 TYP
20 REF
TYP 3 PLACES
TYP
1 TYP
47
FOR -61
(-115)
(FOR -61)
EOP -61
(-163)
(FOR -61 16 PLACES)
PRIMARY
ROLLING
DIRECTION
Y
Z
A
TYP
STOCK
REF
110
FOR -59
29
50
71
92
10
8
-113
-101
-117
PRIMER & ADHESIVE
3 TYP
EOP -59
(-101) (FOR -59)
(-163) (FOR -59 40 PLACES)
ASSY -59 & -61
TT802024
A
4
FRAME 2
FRAME 1

3



TYP 6 PLACES
-113
TYP 6 PLCS
-117
-117 STIFFENER TYP 12 PLACES
-118 STIFFENER TYP 6 PLCS
.15 TYP 12 PLACES
54
27
TEST SPECIMEN TYP REF
T802022
3 TYP
20 REF TYP 3 PLACES
1 TYP
TYP
8
10
29
68
10
50
10
STOCK REF
TYP
PRIMARY ROLLING DIRECTION
3 TYP
-113
TYP

ASSY -57

4

2 | 1

B

C

B

A

DOCUMENT RELEASE

J	TT802024	A

SHEET 4 OF 5

2 | 1

8 7

D

C

B

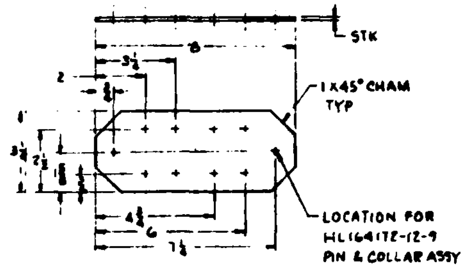
A

8 7

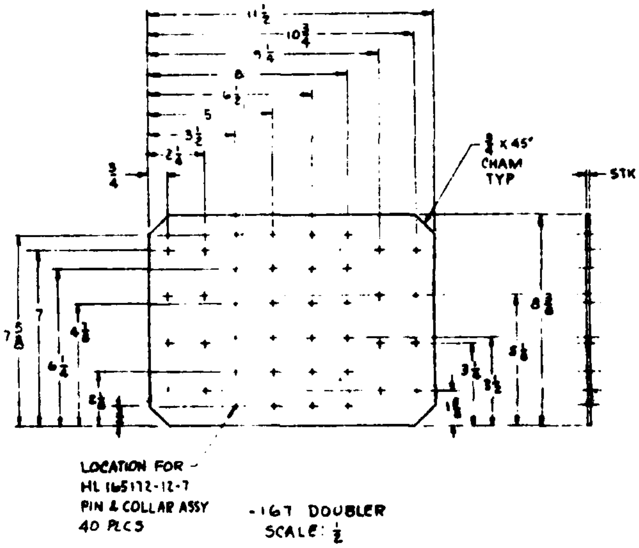
2

1

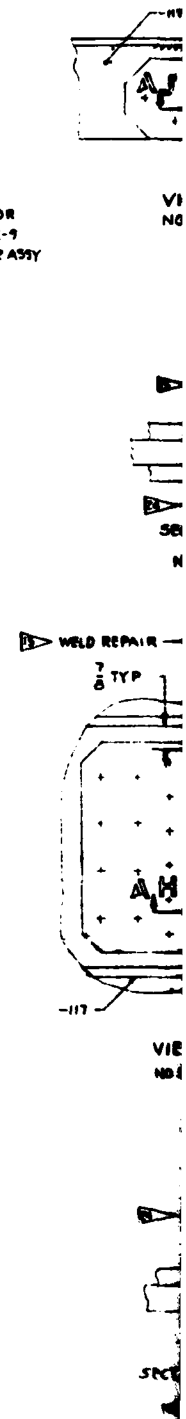
6	5	4



-161 DOUBLER
SCALE: 1/2



-167 DOUBLER
SCALE: 1/2

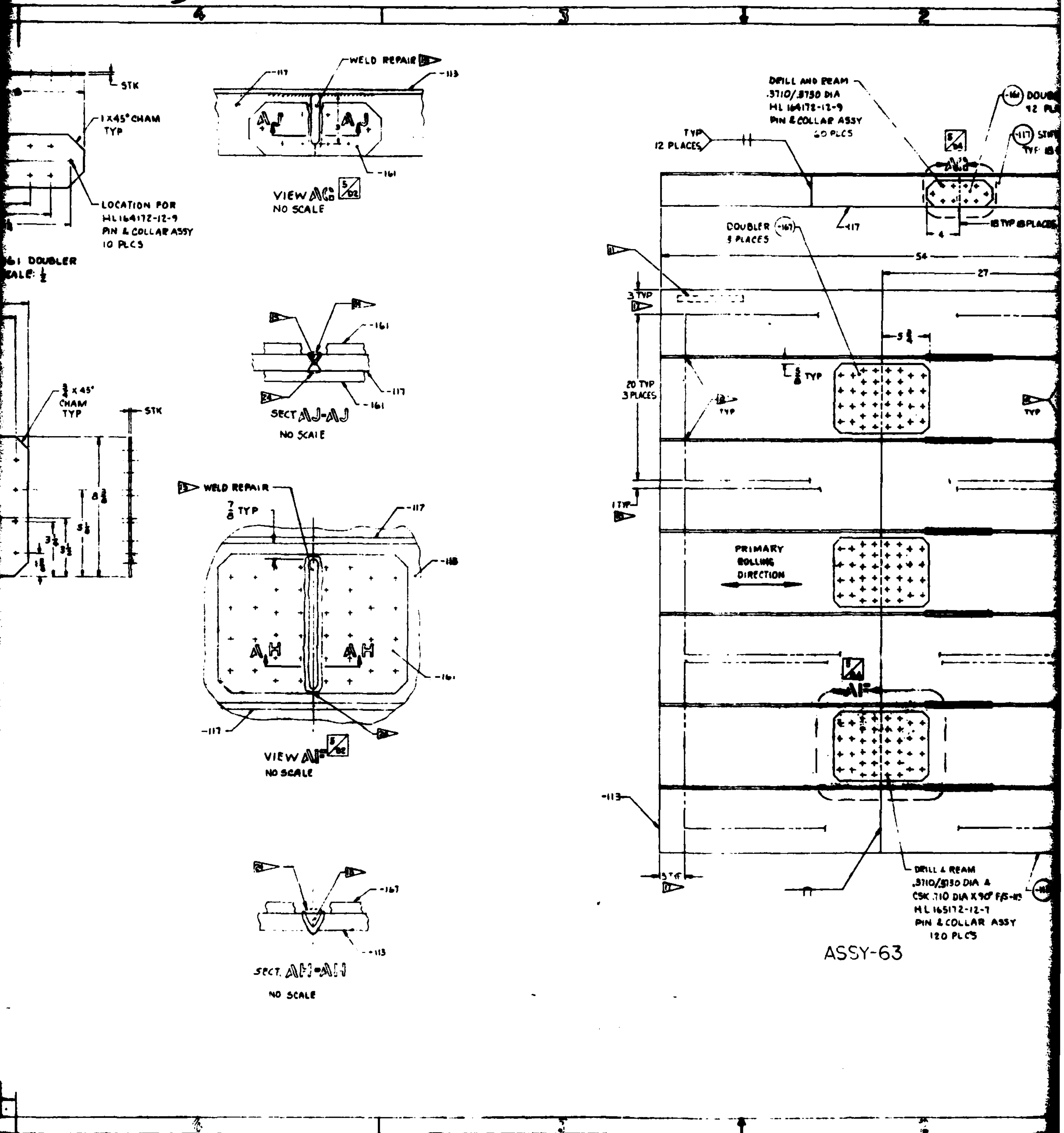


TT802024

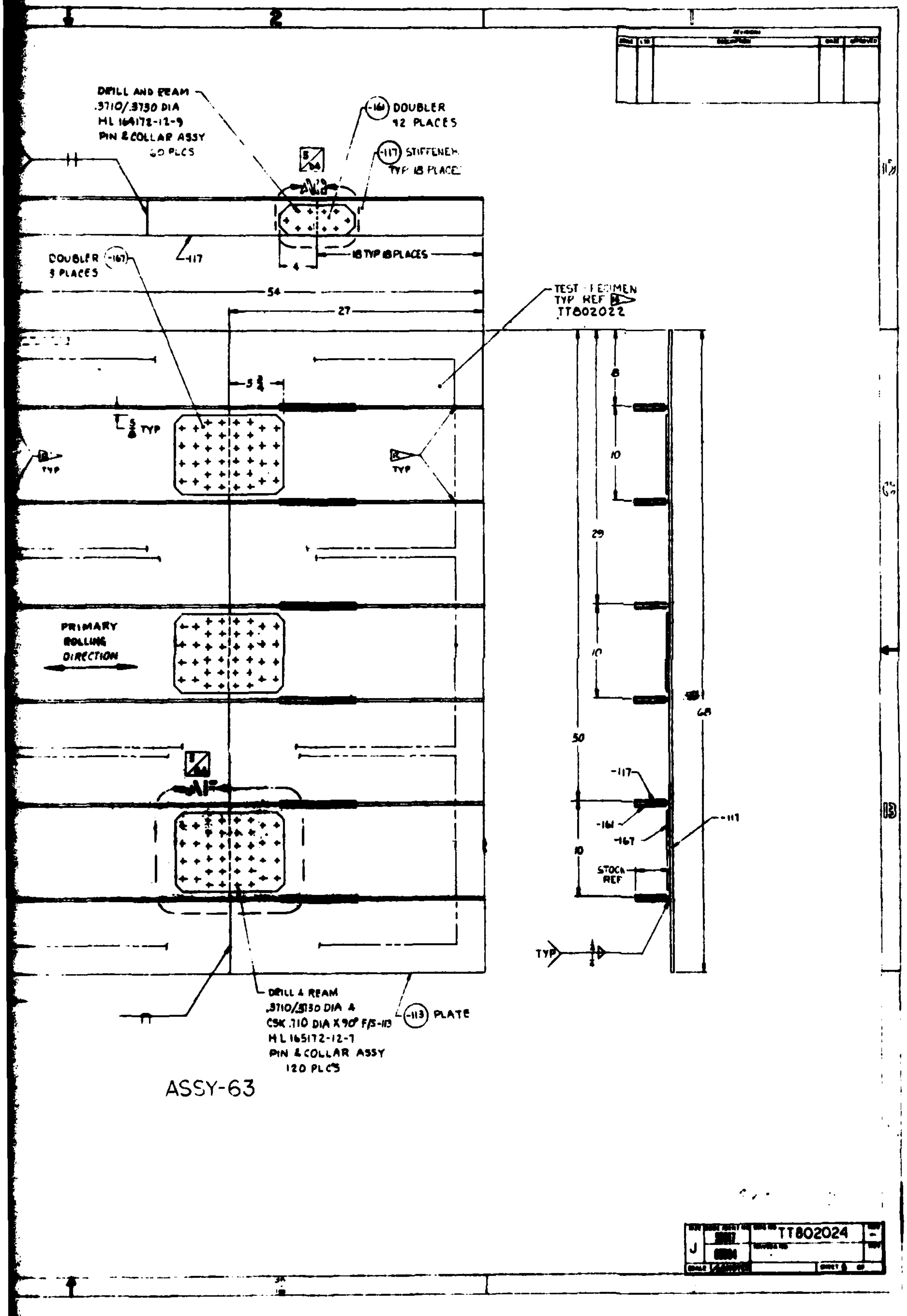
6	5	4

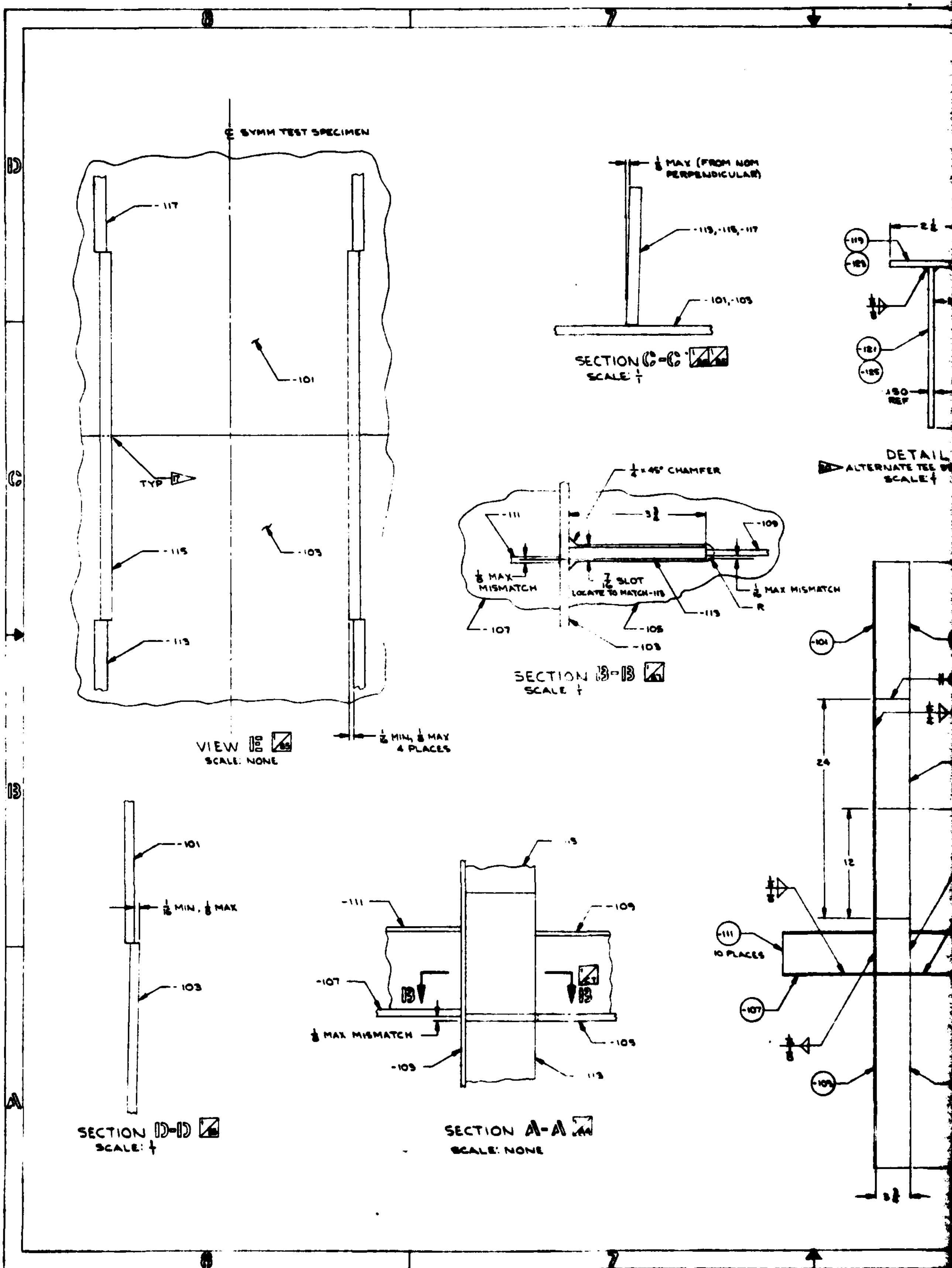
3

1



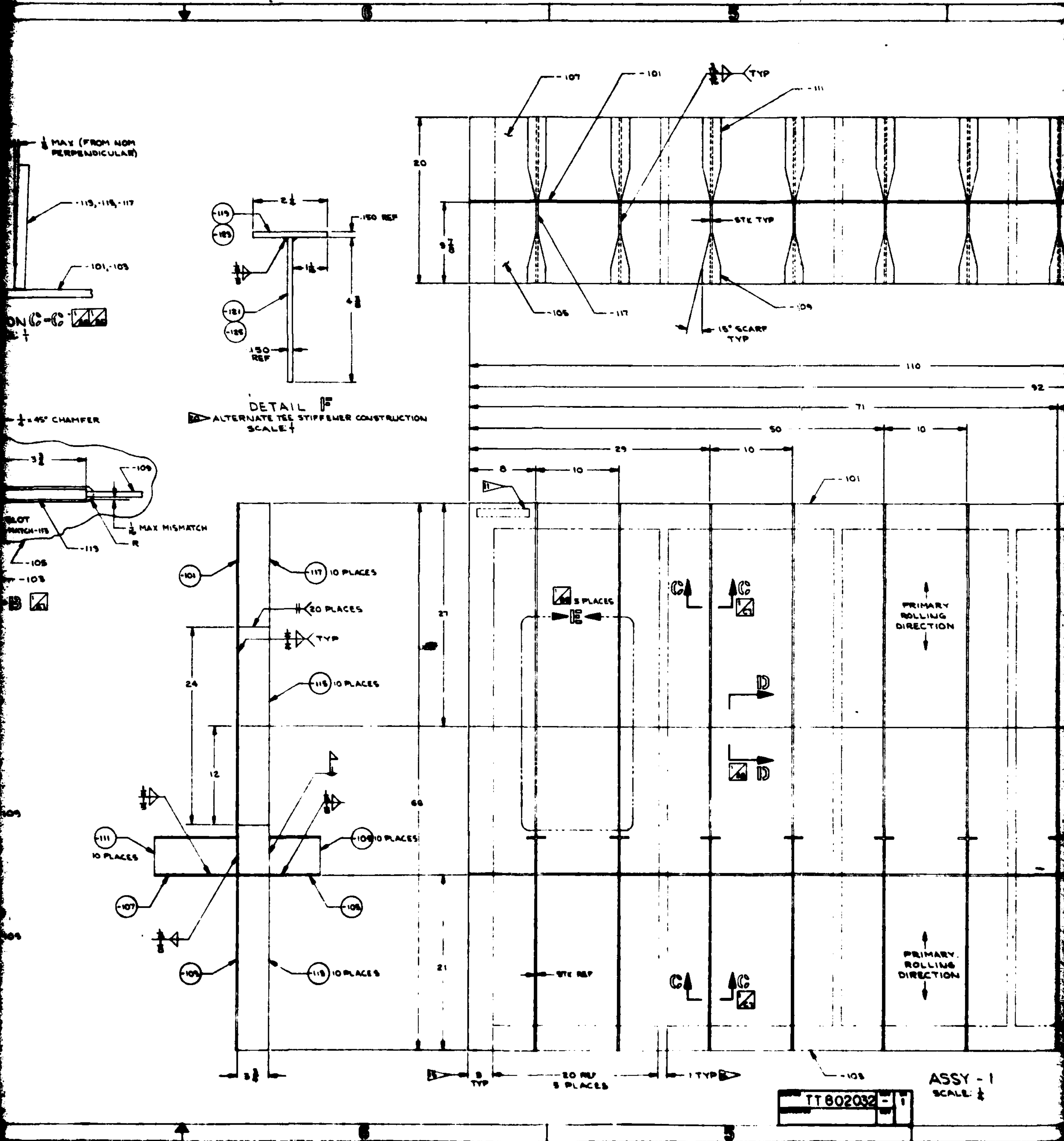
WELD REPAIR
VIEW AG
NO SCALE
SECT AJ-AJ
NO SCALE
VIEW AF
NO SCALE
SECT. AH-AH
NO SCALE
1 X 45° CHAM TYP
LOCATION FOR HL164172-12-9 PIN & COLLAR ASSY 10 PLCS
161 DOUBLER
SCALE: ½
¾ X 45° CHAM TYP
STK
DRILL AND REAM .3710/.3750 DIA HL 164172-12-9 PIN & COLLAR ASSY 60 PLCS
TYP 12 PLACES
DOUBLER (-167) 3 PLACES
54
27
3 TYP
20 TYP 3 PLACES
PRIMARY ROLLING DIRECTION
1 TYP
-113
3 TYP
DRILL & REAM .3710/.3750 DIA & CSK .710 DIA X 90° F/S-113 HL 165172-12-7 PIN & COLLAR ASSY 120 PLCS
ASSY-63


DRILL AND REAM .3710/.3730 DIA HL 164172-12-9 PIN & COLLAR ASSY 60 PLCS
(-161) DOUBLER 42 PLACES
(-117) STIFFENER TYP 18 PLACES
DOUBLER (-167) 3 PLACES
18 TYP 18 PLACES
54
27
TEST SPECIMEN TYP REF
TT802022
PRIMARY ROLLING DIRECTION
DRILL & REAM .3710/.3730 DIA & CSK .710 DIA X 90° F/S-113 HL 165172-12-7 PIN & COLLAR ASSY 120 PLCS
(-113) PLATE
STOCK REF
ASSY-63
TT802024
4



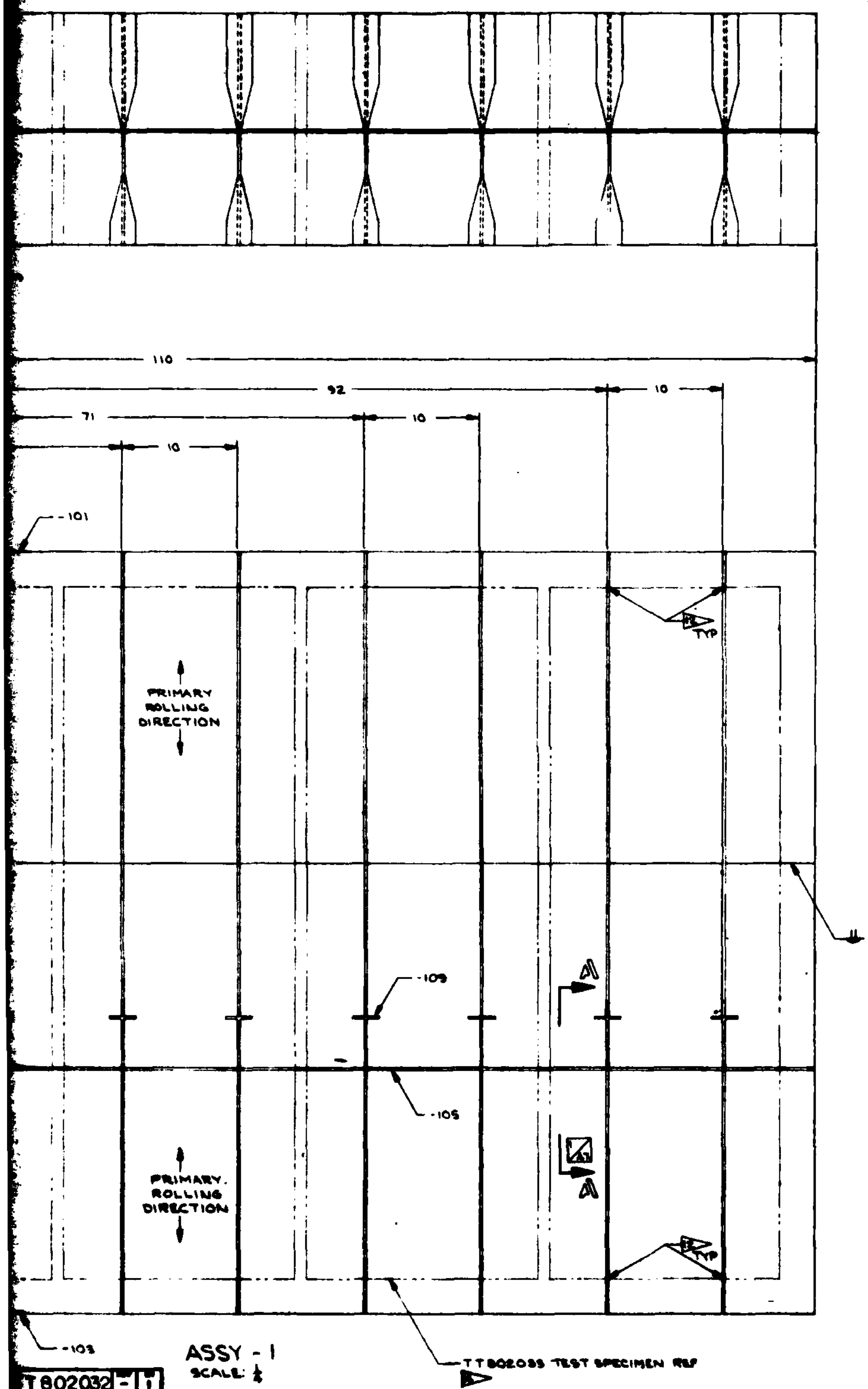
℄ SYMM TEST SPECIMEN
-117
-101
TYP
-115
-103
-113
VIEW E
SCALE: NONE
1/16 MIN, 1/8 MAX 4 PLACES
1/8 MAX (FROM NOM PERPENDICULAR)
-113,-115,-117
-101,-103
SECTION C-C
SCALE: 1/1
1/4 x 45° CHAMFER
-111
3 1/2
-109
1/8 MAX MISMATCH
7/16 SLOT LOCATE TO MATCH-113
1/8 MAX MISMATCH
-113
R
-107
-105
-103
SECTION B-B
SCALE 1/1
-101
1/16 MIN, 1/8 MAX
-103
SECTION D-D
SCALE: 1/4
-113
-111
-109
-107
1/8 MAX MISMATCH
-105
-103
-113
SECTION A-A
SCALE: NONE
DETAIL
ALTERNATE TEE
SCALE 1/4
2 1/2
.50 REF
24
12
-111
10 PLACES
-107
-109
3 1/2

2 1



6
5
1/8 MAX (FROM NOM PERPENDICULAR)
-113, -115, -117
-101, -103
SECTION C-C
-1/2 x 45° CHAMFER
-109
1/8 MAX MISMATCH
R
-105
-103
DETAIL F
ALTERNATE TEE STIFFENER CONSTRUCTION
SCALE 1/4
.150 REF
-107
-101
TYP
-111
STK TYP
-105
-117
-109
15° SCARF TYP
110
92
71
50
29
10
8
-101
10 PLACES
20 PLACES
TYP
5 PLACES
PRIMARY ROLLING DIRECTION
STK REF
-103
20 REF 5 PLACES
1 TYP
TYP
ASSY - 1
SCALE: 1/8
TT 802032

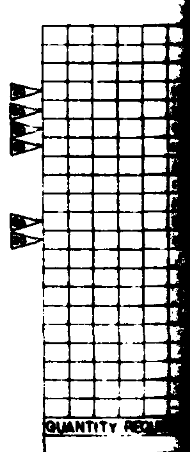
3



ASSY - 1
SCALE: ½

NOTES:

1. BREAK ALL SHARP EDGES .015 R MAX.
2. ALL FABRICATION PROCEDURES TO BE DOCUMENTED FOR ENGINEERING REFERENCE.
3. UNLESS OTHERWISE SPECIFIED, ALL FABRICATION, WELDING & INSPECTION TO BE PER NAVSEA 0900-LP-060-4010.
4. WELD SYMBOLS PER AWS-A-2.0
5. ALL WELDING MUST BE PER PROCEDURES QUALIFIED IN ACCORDANCE WITH MIL-STD-248.
6. NO WELD REPAIRS OF IMPERFECTIONS ARE PERMISSIBLE WITHOUT SPECIFIC STRUCTURES ENGINEERING APPROVAL.
7. COGNIZANT STRUCTURES ENGINEER TO WITNESS FIRST ARTICLE WELDING.
8. AFTER ALL WELDING INCLUDING ANY WELD REPAIR OPERATIONS ARE COMPLETED, STRAIGHTENING (IF REQUIRED) SHALL BE THE MINIMUM NECESSARY TO MEET SPECIFIED DRAWING TOLERANCES. ALL STRAIGHTENING PROCEDURES TO BE FULLY DOCUMENTED INCLUDING BEFORE AND AFTER CONDITIONS.
9. SURFACE INSPECTION CRITERIA FOR ALL WELDS TO BE PER NAVSEA 0900-LP-003-8000 CLASS 3 MINIMUM BASED ON 100% VISUAL INSPECTION.
10. ALL INSPECTIONS TO BE FULLY DOCUMENTED INCLUDING PROCEDURES, GENERAL DESCRIPTIONS & LOCATIONS OF ACCEPTABLE IMPERFECTIONS & DETAILED NATURE, SIZES, & LOCATIONS OF ALL IMPERFECTIONS EXCEEDING ACCEPTANCE STANDARDS.
11. PERMANENTLY IDENTIFY ASSEMBLY IN APPROX. LOCATION SHOWN USING ¼ IN MIN HIGH CHARACTERS. IDENT TO CONSIST OF LAST 3 DIGITS OF DRAWING NUMBER FOLLOWED BY ASSY DASH NO., E.G. 032-1.
12. FINISHED PANEL ASSY SURFACE FLATNESS FOR EACH TEST SPECIMEN REGION SHALL NOT DEVIATE MORE THAN 0.125 T.I.R FROM A FLAT PLANE ESTABLISHED BY PLACING THE PANEL ON HEIGHT BLOCKS AT ALL 4 NOTED POINTS LOCATED ON THE PANEL SURFACE OPPOSITE THE STIFFENERS USING HAND PRESSURE ONLY APPLIED AT ANY CORNER NECESSARY TO PRODUCE CONTACT. THE PORTIONS OF PANEL EXTENDING BEYOND THE AREA OF MEASUREMENT SHALL BE SUPPORTED TO SUSTAIN ANY OVERHANGING WEIGHT.
13. ALL PANEL ASSEMBLY AND WELD SEQUENCING SHALL BE PERFORMED IN THE MANNER PLANNED FOR BKSES PRODUCTION.
14. FINAL TRIM LINES FOR SPECIMENS DEFINED ON NOTED DWG.
15. TRIM AND WELD RUNOUT ALLOWANCE.
16. CUTTING ALLOWANCE.



T802032 | - | 1

EDGES .015 R MAX
PROCEDURES TO BE DOCUMENTED FOR
RENCE.
E SPECIFIED ALL FABRICATION, WELDING &
PER NAVSEA 0900-LP-060-4010.
ER AWS-A-2.0
BE PER PROCEDURES QUALIFIED IN
H MIL-STD-248.
OF IMPERFECTIONS ARE PERMISSIBLE
E STRUCTURES ENGINEERING APPROVAL.
STURES ENGINEER TO WITNESS FIRST
.
NG INCLUDING ANY WELD REPAIR OPERA-
ETED, STRAIGHTENING (IF REQUIRED) SHALL
NECESSARY TO MEET SPECIFIED DRAWING
STRAIGHTENING PROCEDURES TO BE FULLY
UDING BEFORE AND AFTER CONDITIONS.
ON CRITERIA FOR ALL WELDS TO BE PER
003-8000 CLASS 3 MINIMUM BASED ON
ECTION.
TO BE FULLY DOCUMENTED INCLUDING
ERAL DESCRIPTIONS & LOCATIONS OF
RFECTIONS & DETAILED NATURE, SIZES,
LL IMPERFECTIONS EXCEEDING ACCEPT-
.
ENTIFY ASSEMBLY IN APPROX. LOCATION
MIN HIGH CHARACTERS IDENT TO CON-
GITS OF DRAWING NUMBER FOLLOWED BY
6 052-L
SY SURFACE FLATNESS FOR EACH TEST
SHALL NOT DEVIATE MORE THAN 0.125 T.I.R.
AS ESTABLISHED BY PLACING THE PANEL
KS AT ALL 4 NOTED POINTS LOCATED ON
CE OPPOSITE THE STIFFENERS USING HAND
APPLIED AT ANY CORNER NECESSARY TO
T. THE PORTIONS OF PANEL EXTENDING
OF MEASUREMENT SHALL BE SUPPORTED
RHANGING WEIGHT
LY AND WELD SEQUENCING SHALL BE PER-
NNER PLANNED FOR 3KSES PRODUCTION.
FOR SPECIMENS DEFINED ON NOTED DWG.
RUNOUT ALLOWANCE.
ANCE.

17. WHERE A STIFFENER IS FILLET WELDED ACROSS A PLATE BUTT WELD, THE BUTT WELD SHALL FIRST BE SHAVED FLUSH TO 1/32 IN. ABOVE THE BASE METAL ON THE HIGHER SIDE OF THE BUTT JOINT FOR 1 IN. ON EACH SIDE OF THE FILLET WELD LOCATION.

18. 100% RADIOGRAPHIC INSPECTION OF ALL BUTT WELDS TO BE PERFORMED PER MIL-STD-271. ACCEPTANCE CRITERIA TO BE PER NAVSEA 0900-LP-003-9000 CLASS 3 MIN.

19. MATERIAL WHICH REQUIRES CHEM-MILLING TO ACHIEVE THE SPECIFIED THICKNESS SHALL BE ORDERED SUFFICIENTLY OVERSIZE IN ORDER TO PROVIDE A MINIMUM 1 IN. TRIM BACK ON ALL EDGES AFTER CHEM-MILLING.

20. WELD-FABRICATED SECTIONS OF 5456-H116/H117 AL ALY AS SHOWN ON DETAIL "F" ZONE C6 MAY BE SUBSTITUTED IF TL 101004-104 EXTRUSION SECTION IS NOT AVAILABLE. ALTERNATE EXTRUSION SECTIONS MAY ALSO BE USED WITH THE APPROVAL OF THE COGNIZANT STRUCTURES ENGINEER.

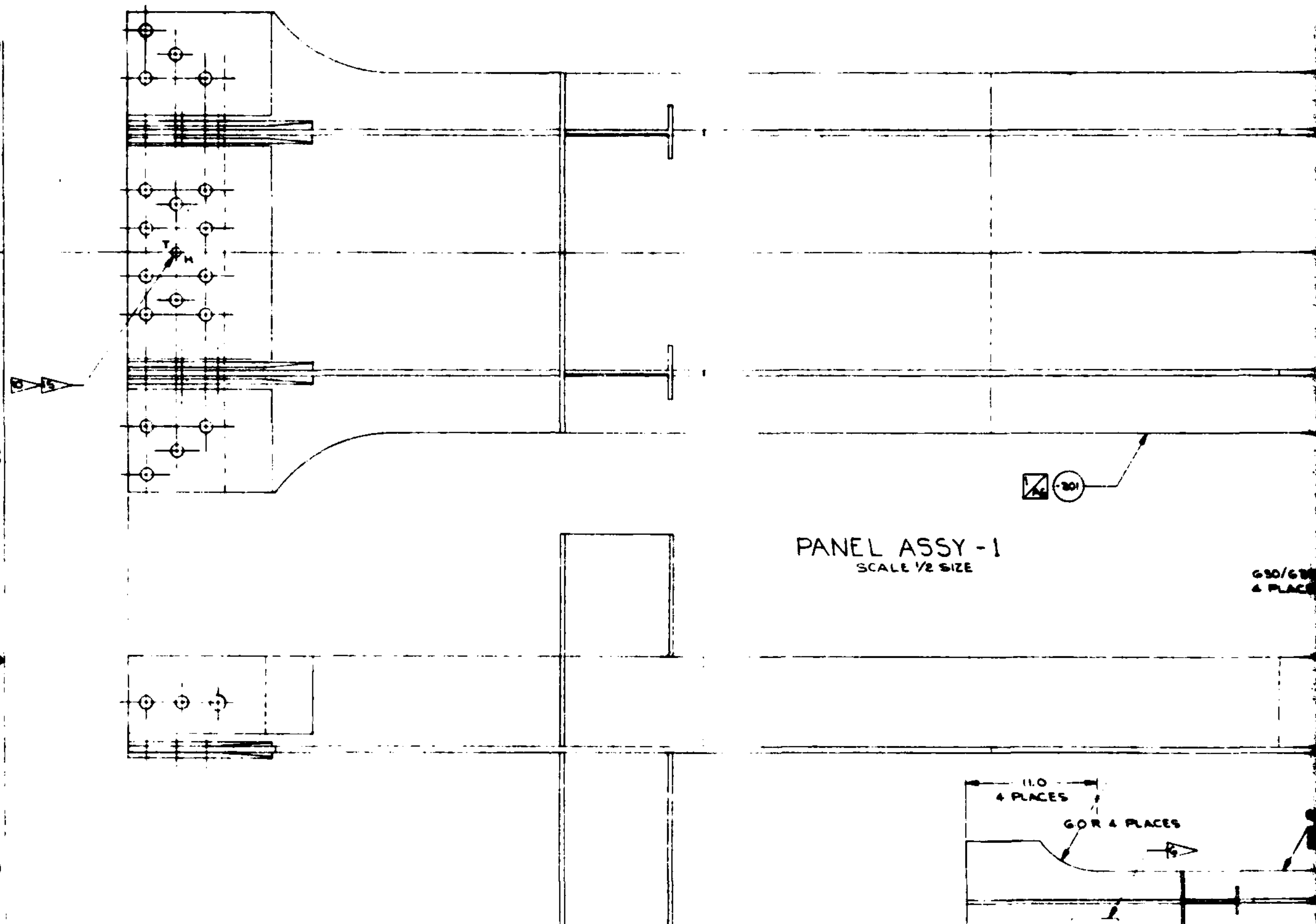
QUANTITY REQUIRED	PART NUMBER		DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
10	-125		PLATE	AL ALY 5456-H116/H117	.190×4 7/8×9 7/8	QQ-A-250/20	19
10	-123		PLATE		.190×2 1/8×9 7/8		19
10	-121		PLATE		.100×4 7/8×6 1/8		19
10	-119		PLATE		.150×2 1/8×6 7/8		19
10	-117		PLATE		.313×3 3/4×15		
10	-115		PLATE		.313×3 3/4×24		
10	-113		PLATE	AL ALY 5456-H116/H117	.313×3 3/4×27	QQ A 250/20	
10	-111		TEE STIFFENER	M/F TL 101004-104	9 7/8 LG		
10	-109		TEE STIFFENER	M/F TL 101004-104	6 1/8 LG		
1	-107		PLATE	AL ALY 5456-H116/H117	.200×9 7/8×110	QQ-A-250/20	19
1	-105		PLATE		.200×9 7/8×110		19
1	-103		PLATE		.250×39×110		
1	-101		PLATE	AL ALY 5456-H116/H117	.250×27×110	QQ-A-250/20	
—	-1		PANEL ASSY				
-1							

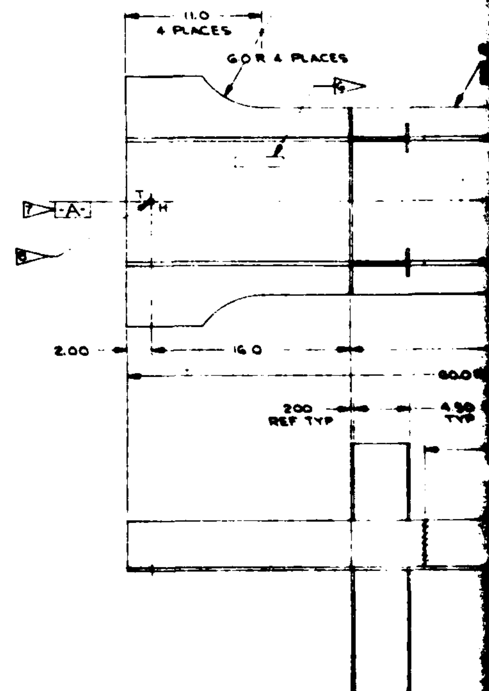
PARTS LIST

ALL MACHINED SURFACES 250/ UNLESS OTHERWISE SPECIFIED

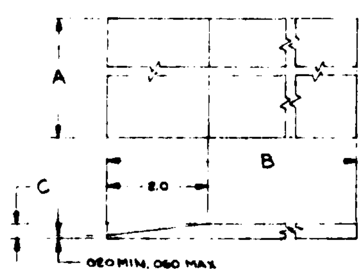
FAB ASSEMBLY
DECK/BULKHEAD INTERSECT.
STRUCT. ELEMENT TEST

J TT802032 —

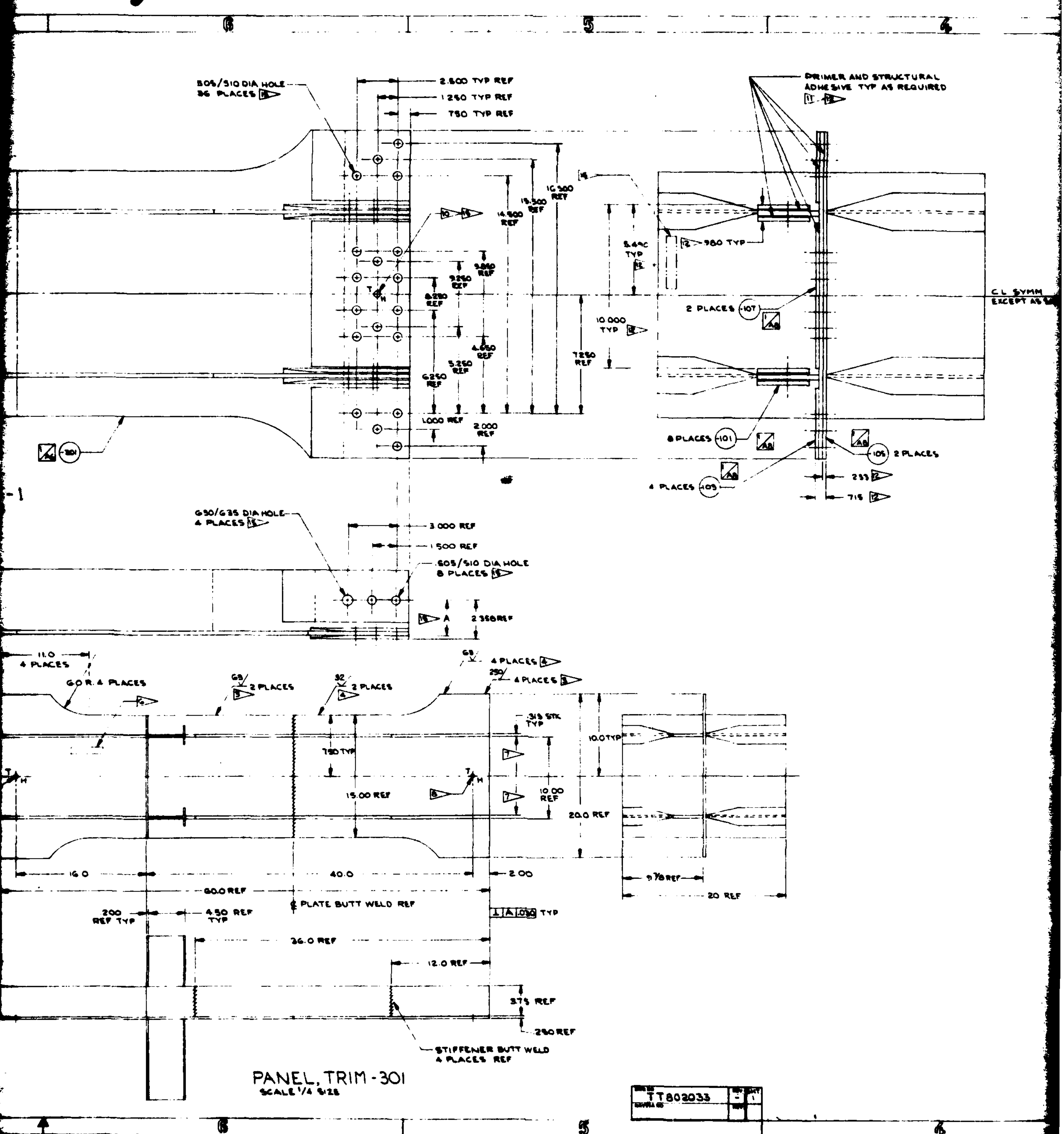




DASH NO	DOUBLER DIM. TABLE A	B	C
-101	3.2	7.7	.250
-103	4.3	6.0	.190
-105	20.0	6.0	.190
-107	8.9	6.0	.190

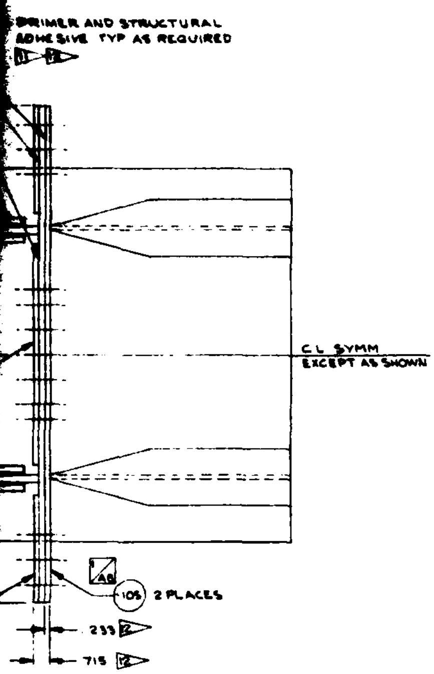


DETAIL -101 THRU -107
SCALE: NONE



PANEL, TRIM - 301
SCALE 1/4 SIZE

3



NOTES:

1. TTB02032 LARGE ASSEMBLY TO BE SUPPLIED BY STRUCTURES ENGINEERING. CUT SPECIMEN BLANKS AND TRIM TO SIZE SHOWN ON F/D LAYOUT OF SPECIMEN BLANKS TO BE COORDINATED WITH COGNIZANT STRUCTURES ENGINEER
2. BREAK SHARP EDGES. DO NOT FINISH, POLISH OR REMOVE IMPERFECTIONS FROM ANY SPECIMEN FLAT SURFACES
3. STATIC TEST ONLY
4. FATIGUE TEST SPECIMENS ONLY - ROUND OFF CORNERS AND HAND POLISH PLATE EDGES OVER FULL LENGTH OF REDUCED WIDTH SECTION TO REMOVE ALL NICKS, SCRATCHES AND OTHER IMPERFECTIONS (32/MIN)
5. DESIGNATION OF STATIC TEST AND FATIGUE TEST SPECIMENS TO BE OBTAINED FROM COGNIZANT STRUCTURES ENGINEER
6. IDENTIFY EACH PANEL IN APPROX LOCATION SHOWN USING INK MARKINGS WITH 1/4 IN. MIN HIGH CHARACTERS. IDENT TO CONSIST OF LAST 3 DIGITS OF DWG NO, PANEL DASH NO AND "S" FOR STATIC TEST OR "F" FOR FATIGUE TEST e.g. 033-301-S
7. DATUM -A- TO BE CENTERED WITHIN .010 BETWEEN STIFFENER BASE INNER FACES (ABOVE FILLET WELD BEADS) AT EACH TOOLING HOLE "T◆H" LOCATION ON FINAL TRIMMED PANEL. LIGHTLY SCRIBE 8 IN LENGTH LINES LOCATED THROUGH CENTER OF TOOLING HOLES PERPENDICULAR TO PANEL END TRIM ON STIFFENER SIDE OF PLATE STARTING AT AT EACH END OF PANEL
8. .3751/.3755 DIA TOOLING HOLE LOCATED AS SHOWN
9. (NOT USED)
10. BEFORE BONDING DOUBLERS, LOCATE AND DRILL .375/.380 DIA HOLES IN -105 AND -107 DOUBLERS TO MATCH LOCATION OF PANEL TOOLING HOLES "T⊕H"
11. PREPARE DOUBLERS AND PANEL ENDS FOR BONDING IN ACCORDANCE WITH ROHR MPD 02004. WITHIN 1 HOUR AFTER CLEANING, APPLY A THIN COATING OF PRIMER TO BONDING SURFACE AND DRY 1 HOUR AT 75° F. APPLY PRIMER AS RECEIVED ONLY SUFFICIENT TO WET THE BONDING SURFACES
12. BOND PRIMED DOUBLERS TO PRIMED SPECIMEN PER MANUFACTURERS INSTRUCTIONS - MAINTAIN THICKNESS AND LOCATION DIMENSIONS SHOWN ON F/D USING TOOLING AS REQUIRED
13. SMALL QUANTITIES OF CAB-O-SIL (CABOT CORP) MAY BE ADDED TO ADHESIVE TO INCREASE VISCOSITY FOR EASE OF HANDLING
14. HYSOL DIVISION, THE DEXTER CORP, LOS ANGELES, CA
15. USING THE TOOLING HOLE "T⊕H" AT EACH END OF THE SPECIMEN, LOCATE AND DRILL ALL REMAINING END FIXTURE ATTACHMENT HOLES IN EACH END OF SPECIMEN, USING DRILL FIXTURE NO TTB02029. ADD SPACERS AND/OR SHIMS AS REQUIRED TO TOOLING FIXTURE TO SET "A" DIMENSION PROVIDED BY COGNIZANT STRUCTURES ENGINEER
16. PERMANENTLY IDENTIFY EACH SPECIMEN IN APPROX LOCATION SHOWN USING 1/4 IN HIGH MIN CHARACTERS. IDENT TO CONSIST OF LAST 3 DIGITS OF DRAWING NO., SPECIMEN DASH NO. "S" FOR STATIC TEST OR "F" FOR FATIGUE TEST, AND REPLICATE NO., e.g. 033-1-#1
17. DOUBLER MATERIAL AND GAGE SUBSTITUTIONS ARE PERMITTED WITH APPROVAL OF COGNIZANT STRUCTURES ENGINEER

QUANTITY REQUIRED	PART NUMBER	ZONE	DESC
A/R		D4	PRIM
A/R		D4	ADHE
1	-301	A5	PANE
2	-107	C6	DOUB
2	-105	C6	
4	-103	C6	
8	-101	C6	DOUB
-	-1	C7	PANE
-1			

4 3 2

4

...LIED BY STRUCTURES
...RIM TO SIZE SHOWN ON
...DINATED WITH

... REMOVE IMPERFECT-

... CORNERS AND HAND
... REDUCED WIDTH
...AND OTHER IMPERFEC-

...E TEST SPECIMENS TO
... ENGINEER
... SHOWN USING INK
...ERS IDENT TO CONSIST
...AND 5 FOR STATIC
...S
...EEN STIFFENER BASE
... AT EACH TOOLING
..., LIGHTLY SCRIBE 8 IN
...LING HOLES PERPEN-
...E OF PLATE STARTING AT

... SHOWN

...LL .375/.380 DIA HOLES
...TION OF PANEL TOOLING

...NDING IN ACCORDANCE
...FTER CLEANING, APPLY
...SURFACE AND DRY 1 HOUR
...Y SUFFICIENT TO WET

...N PER MANUFACTURERS
... LOCATION DIMENSIONS
...RED
...P) MAY BE ADDED TO
...SE OF HANDLING
...ANGELES, CA
...END OF THE SPECIMEN,
...XTURE ATTACHMENT
... FIXTURE NOTT 802029
... TO TOOLING FIXTURE TO
...T STRUCTURES ENGINEER
... APPROX LOCATION SHOWN
... TO CONSIST OF LAST 3
...S FOR STATIC TEST OR "F" FOR

...IONS ARE PERMITTED
...SS ENGINEER

PARTS LIST

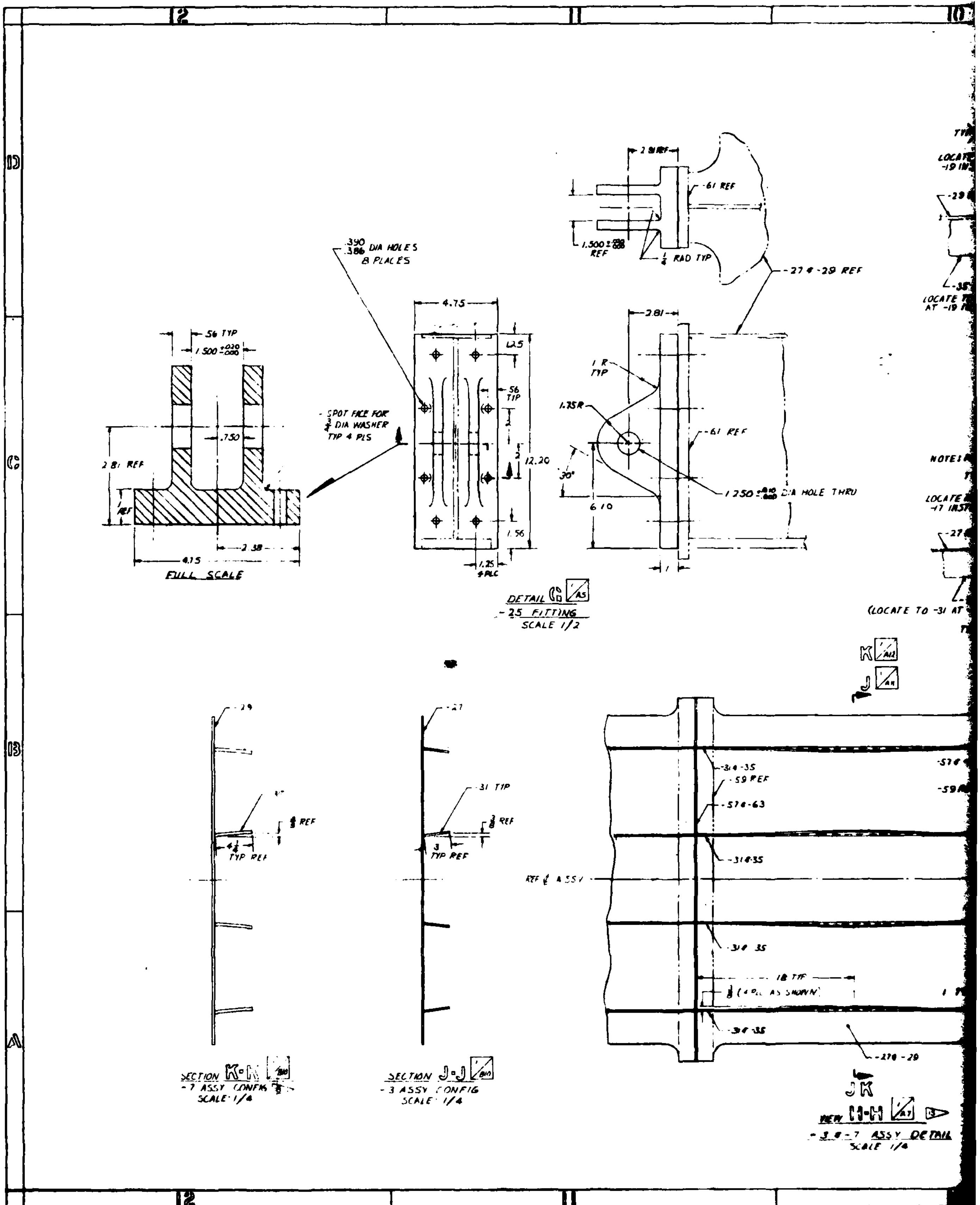
QUANTITY REQUIRED -1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
A/R		D4	PRIMER	HYSOL EA 9203		14	
A/R		D4	ADHESIVE	HYSOL EA 9309.2		14	13
1	-301	A6	PANEL, TRIM	M/FTT 802032-1	1		
2	-107	C5	DOUBLER 17	7075-T6 AL ALY SH	.190×6.0×8.9	QQ-A-250/12	
2	-105	C4		7075-T6 AL ALY SH	.190×6.0×20.0		
4	-103	C5		7075-T6 AL ALY SH	.190×4.3×6.0		
8	-101	C6	DOUBLER 17	7075-T651 AL ALY PL	.250×3.2×7.7	QQ-A-250/12	
–	-1	E7	PANEL ASSY				

ALL MACHINED SURFACES 250√ UNLESS OTHERWISE SPECIFIED

TEST ARTICLE ASSEMBLIES - DECK/BULKHEAD INTERSECTIONS, TENSILE, STATIC AND FATIGUE TESTS

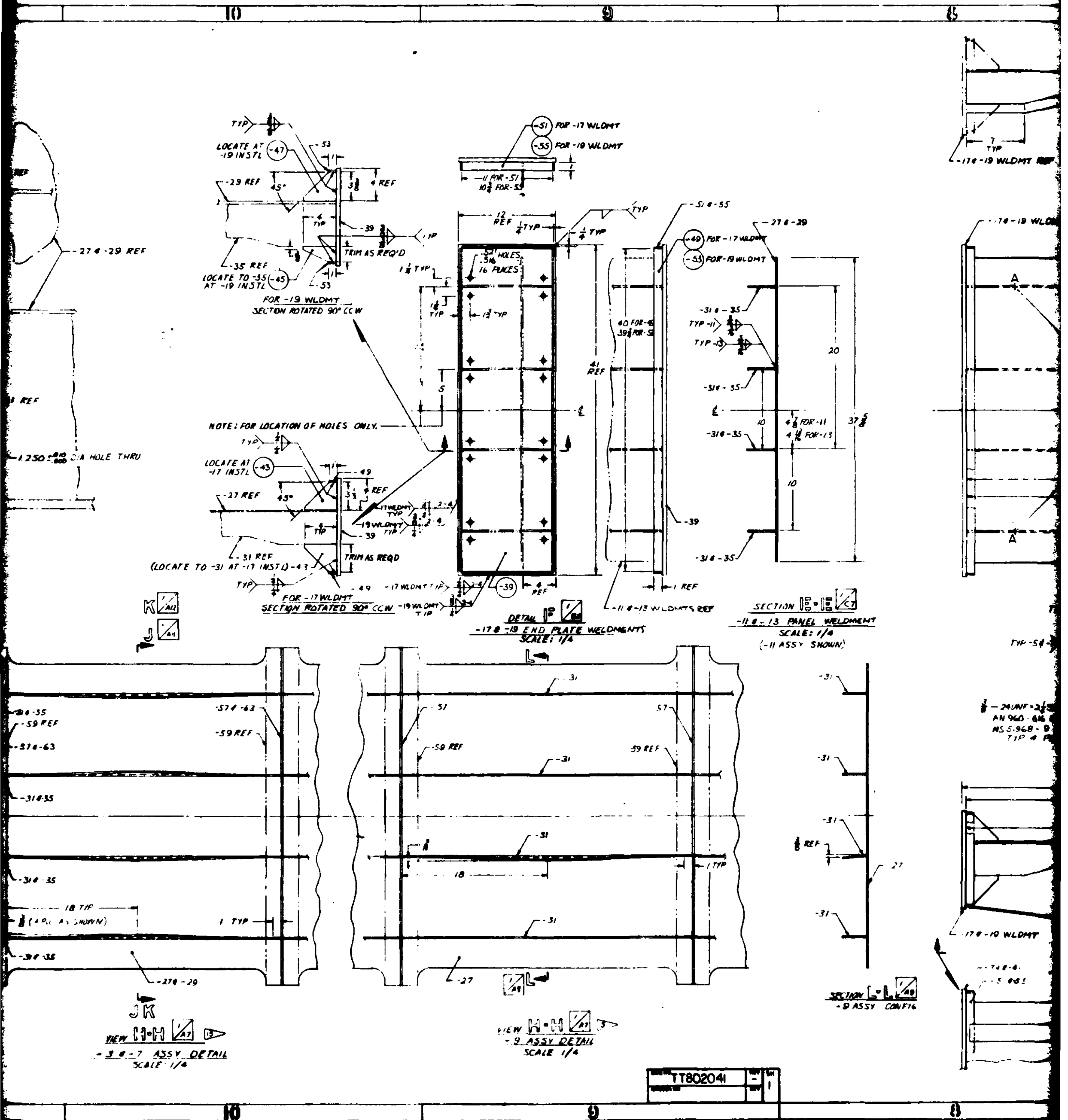
J TT802033 -

SCALE NOTED



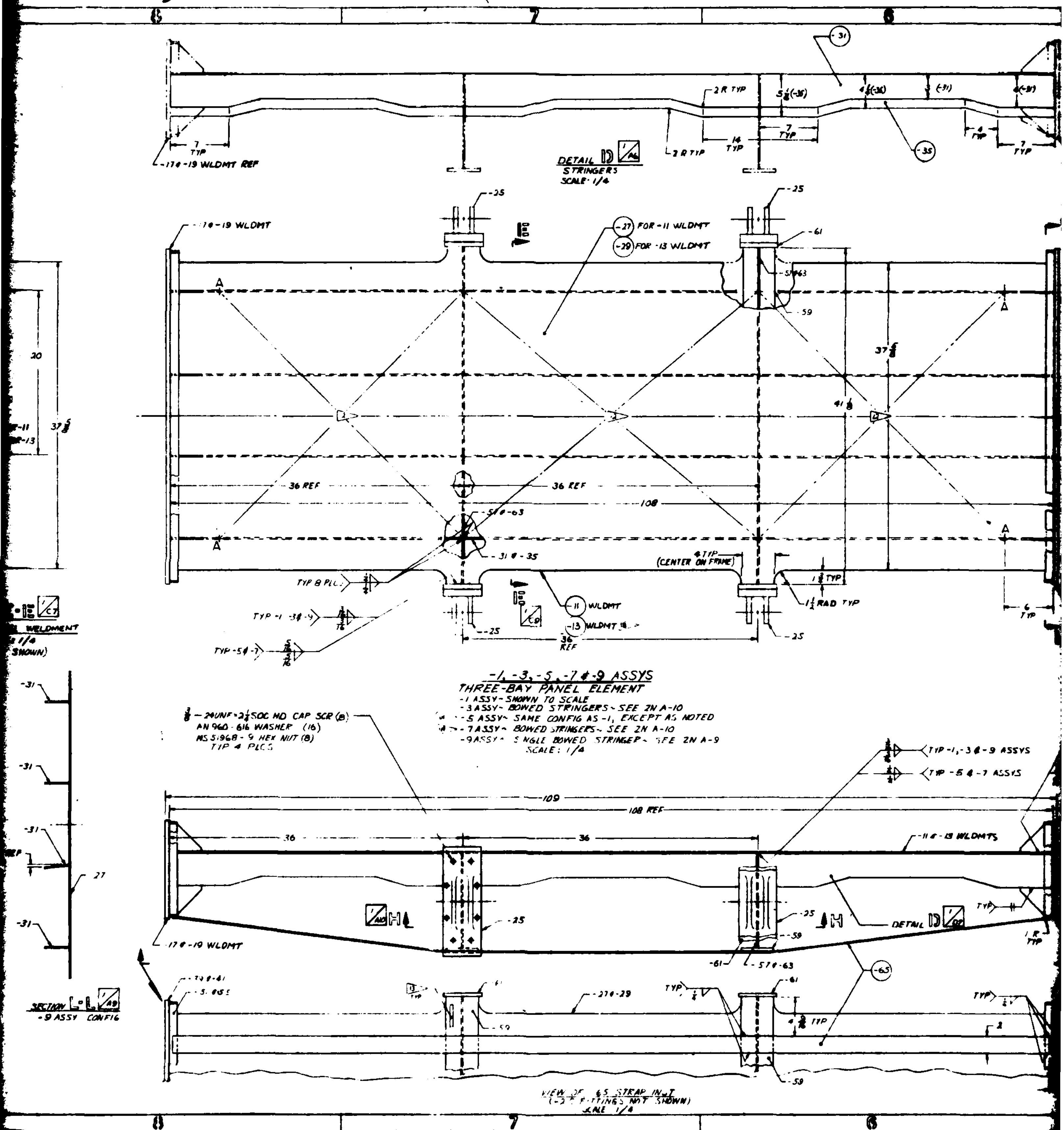
12
11
10
D
C
B
A
2.81 REF
-.61 REF
1.500 REF
1/4 RAD TYP
-27 & -29 REF
.390 .386 DIA HOLES 8 PLACES
4.75
.56 TYP
1.500
.750
2.81 REF
1 REF
2.38
4.15
FULL SCALE
SPOT FACE FOR 3/4 DIA WASHER TYP 4 PLS
1.25
.56 TYP
12.20
1.56
1.25 4 PLC
2.81
1 R TYP
1.75R
-.61 REF
30°
6.10
1.250 DIA HOLE THRU
DETAIL C
-25 FITTING
SCALE 1/2
LOCATE TO -31 AT
NOTES
K
J
-29
-27
-31 TYP
3/8 REF
TYP REF
3 TYP REF
-31 & -35
-59 REF
-57 & -63
-31 & 35
REF ℄ ASSY
18 TYP
-27 & -29
SECTION K-K
-7 ASSY CONFIG
SCALE 1/4
SECTION J-J
-3 ASSY CONFIG
SCALE 1/4
VIEW H-H
-3 & -7 ASSY DETAIL
SCALE 1/4

2



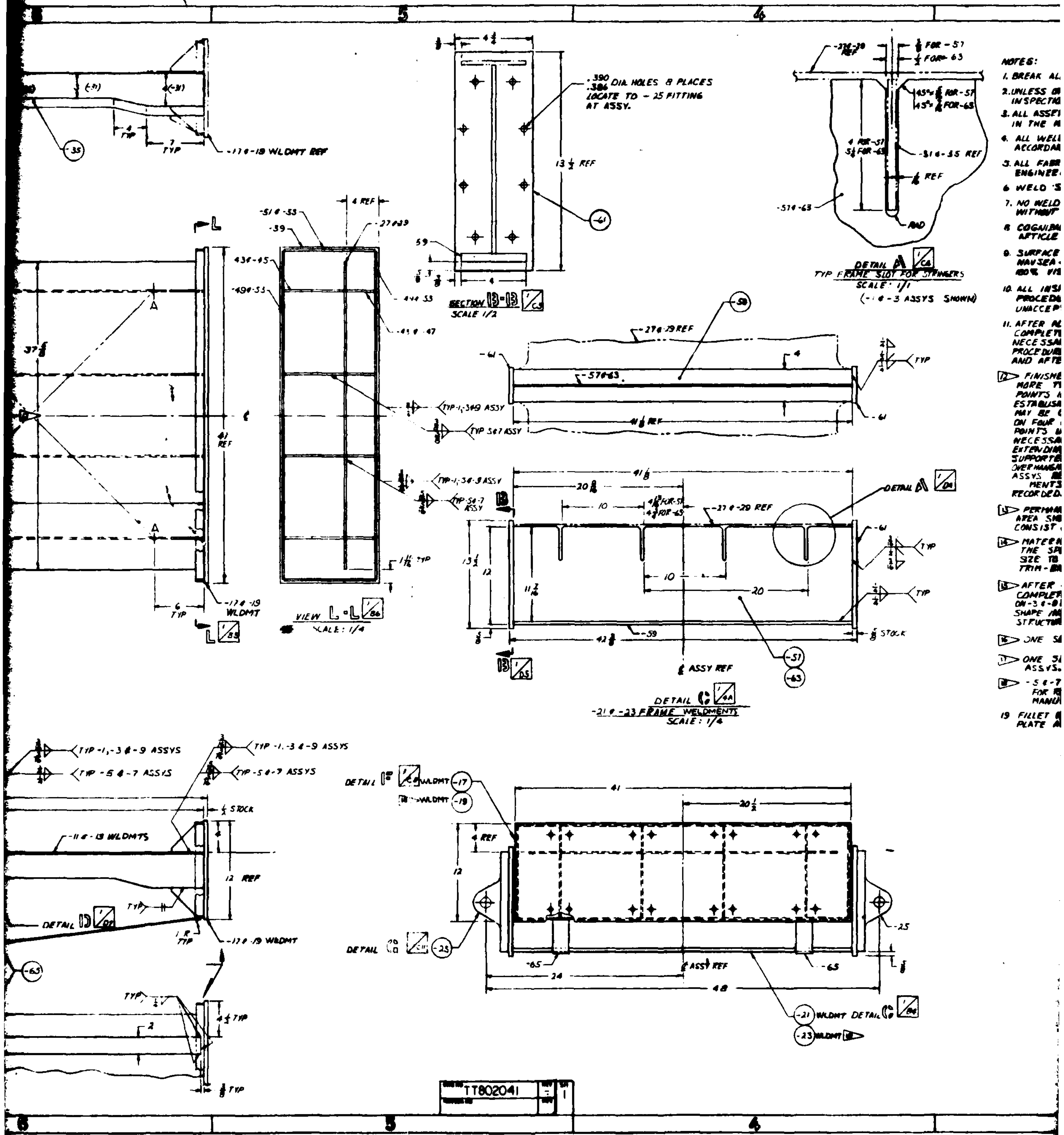
10
9
8
FOR -19 WLDMT
SECTION ROTATED 90° CCW
LOCATE AT -19 INSTL -47
LOCATE TO -35 AT -19 INSTL -45
-29 REF
-35 REF
-27 & -29 REF
TRIM AS REQ'D
-51 FOR -17 WLDMT
-55 FOR -19 WLDMT
-11 FOR -51
10 3/4 FOR -55
.516 HOLES 16 PLACES
NOTE: FOR LOCATION OF HOLES ONLY.
41 REF
LOCATE AT -17 INSTL -43
-27 REF
-31 REF
(LOCATE TO -31 AT -17 INSTL) -43
TRIM AS REQD
FOR -17 WLDMT
SECTION ROTATED 90° CCW
DETAIL
-17 & -19 END PLATE WELDMENTS
SCALE: 1/4
-49 FOR -17 WLDMT
-53 FOR -19 WLDMT
-51 & -55
-27 & -29
40 FOR -49
39 3/4 FOR -53
-11 & -13 WLDMTS REF
1 REF
-39
-31 & -35
20
4 1/8 FOR -11
4 1/2 FOR -13
37 5/8
10
SECTION
-11 & -13 PANEL WELDMENT
SCALE: 1/4
(-11 ASSY SHOWN)
-17 & -19 WLDMT REF
1.250 DIA HOLE THRU
-57 & -63
-59 REF
-31 & -35
18 TYP
1 TYP
-27 & -29
VIEW H-H
-3 & -7 ASSY DETAIL
SCALE 1/4
-31
-57
-59 REF
18
-27
VIEW H-H
-9 ASSY DETAIL
SCALE 1/4
SECTION L-L
-9 ASSY CONFIG
3/8 - 24UNF
AN 960
MS 5968
-17 & -19 WLDMT
TT802041

3



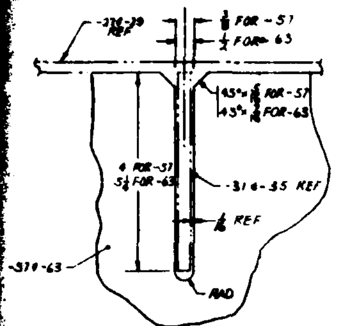
DETAIL D
STRINGERS
SCALE 1/4
-17 & -19 WLDMT REF
-27 FOR -11 WLDMT
-29 FOR -13 WLDMT
-1, -3, -5, -7 & -9 ASSYS
THREE-BAY PANEL ELEMENT
-1 ASSY- SHOWN TO SCALE
-3 ASSY- BOWED STRINGERS- SEE ZN A-10
-5 ASSY- SAME CONFIG AS -1, EXCEPT AS NOTED
-7 ASSY- BOWED STRINGERS- SEE ZN A-10
-9 ASSY- SINGLE BOWED STRINGER- SEE ZN A-9
SCALE: 1/4
3/8 - 24UNF × 2 1/4 SOC HD CAP SCR (8)
AN 960-616 WASHER (16)
MS 51968-9 HEX NUT (8)
TYP 4 PLCS
TYP -1, -3 & -9 ASSYS
TYP -5 & -7 ASSYS
-11 & -13 WLDMTS
-17 & -19 WLDMT
SECTION L-L
-9 ASSY CONFIG
VIEW OF -65 STRAP IN -1
(-27 FITTINGS NOT SHOWN)
SCALE 1/4

41



.390 .386 DIA HOLES 8 PLACES LOCATE TO - 25 FITTING AT ASSY.
SECTION B-B
SCALE 1/2
NOTES:
1. BREAK AL
DETAIL A
TYP FRAME SLOT FOR STRINGERS
SCALE: 1/1
(-1 & -3 ASSYS SHOWN)
VIEW L-L
SCALE: 1/4
DETAIL C
-21 & -23 FRAME WELDMENTS
SCALE: 1/4
-17 & -19 WLDMT REF
-11 & -13 WLDMTS
TYP -1, -3 & -9 ASSYS
TYP -5 & -7 ASSYS
¢ ASSY REF
TT802041

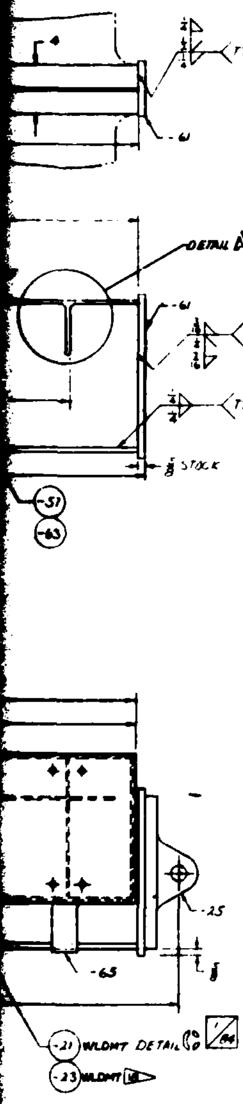
J 5



DETAIL A 1/C6
TYP FRAME SLOT FOR STRINGERS
SCALE 1/1
(-1 & -3 ASSYS SHOWN)

NOTES:

1. BREAK ALL SHARP EDGES .015 R MAX
2. UNLESS OTHERWISE SPECIFIED, ALL FABRICATION WELDING AND INSPECTION TO BE PER NAVSEA 0900-LP-060 4010.
3. ALL ASSEMBLY AND WELD SEQUENCING TO BE PERFORMED IN THE MANNER PLANNED FOR 3KSES PRODUCTION.
4. ALL WELDING MUST BE PER PROCEDURES QUALIFIED IN ACCORDANCE WITH MIL-STD-248.
5. ALL FABRICATION PROCEDURES TO BE DOCUMENTED FOR ENGINEERING REFERENCE.
6. WELD SYMBOLS PER AWS-A-2.0.
7. NO WELD REPAIRS OF IMPERFECTIONS ARE PERMISSIBLE WITHOUT SPECIFIC STRUCTURES ENGINEERING APPROVAL.
8. COGNIZANT STRUCTURES ENGINEER TO WITNESS FIRST ARTICLE WELDING.
9. SURFACE INSPECTION CRITERIA FOR ALL WELDS TO BE PER NAVSEA-0900-LP-003-8000 CLASS 3 MINIMUM BASED ON 100% VISUAL INSPECTION.
10. ALL INSPECTIONS TO BE FULLY DOCUMENTED INCLUDING PROCEDURES AND DESCRIPTIONS AND LOCATIONS OF ALL UNACCEPTABLE IMPERFECTIONS.
11. AFTER ALL WELDING, INCLUDING ANY WELD REPAIRS ARE COMPLETED, STRAIGHTENING (IF REQUIRED) SHALL BE THE MINIMUM NECESSARY TO MEET SPECIFIED LIMITS. ALL STRAIGHTENING PROCEDURES TO BE FULLY DOCUMENTED INCLUDING BEFORE AND AFTER CONDITIONS.
12. FINISHED PANEL ASSY SURFACE FLATNESS SHALL NOT DEVIATE MORE THAN .125 FROM FLAT PLANES ESTABLISHED THROUGH POINTS INDICATED NOR MORE THAN .250 FROM A FLAT PLANE ESTABLISHED THROUGH ALL FOUR POINTS. REFERENCE PLANES MAY BE OBTAINED BY PLACING ASSEMBLY, PLATE SIDE DOWN, ON FOUR HEIGHT BLOCKS LOCATED AT THE APPROPRIATE DESIGNATED POINTS USING HAND PRESSURE ONLY APPLIED AT ANY POINTS NECESSARY TO PRODUCE CONTACT. PORTIONS OF THE ASSEMBLY EXTENDING BEYOND EACH AREA OF MEASUREMENT SHALL BE SUPPORTED IF MEASUREMENT ACCURACY IS AFFECTED BY THE OVERHANGING WEIGHT. FLATNESS CRITERIA SHALL APPLY TO -3, -7 & -9 ASSYS BEFORE STIFFENERS ARE DEFORMED; FLATNESS MEASUREMENTS AFTER DEFORMATION OF THE STIFFENERS SHALL BE RECORDED. (SEE 15)
13. PERMANENTLY IDENTIFY EACH ASSEMBLY IN APPROXIMATE AREA SHOWN USING 1/4 MIN HIGH CHARACTERS; IDENT TO CONSIST OF 041-ASSY DASH NO., e.g. 14-3.
14. MATERIAL WHICH REQUIRES CHEM-MILLING TO PRODUCE THE SPECIFIED THICKNESS SHALL BE SUFFICIENTLY OVERSIZE TO PROVIDE ALLOWANCE FOR A MINIMUM OF 1 INCH TRIM-BACK ON ALL EXPOSED EDGES AFTER CHEM-MILLING.
15. AFTER ALL WELDING AND STRAIGHTENING OPERATIONS ARE COMPLETED AND ACCEPTED, SMOOTHLY DEFORM -31 STRINGERS ON -3 & -9 ASSYS, & -35 STRINGERS ON -7 ASSY TO APPROXIMATE SHAPE INDICATED USING TEMPLATE SUPPLIED BY COGNIZANT STRUCTURES ENGINEER.
16. ONE SET OF FITTINGS (4 ITEMS) USED FOR ALL ASSYS.
17. ONE SET OF BOLTS, WASHERS AND NUTS USED FOR ALL ASSYS.
18. -5 & -7 HEAVY PANEL ELEMENT ASSYS ARE SHOWN FOR REFERENCE ONLY, AND ARE NOT PLANNED FOR MANUFACTURE AT THIS TIME.
19. FILLET WELDS MUST BE CONTINUOUS AROUND EDGE OF PLATE AT ALL CUTOUTS, STIFFENERS, AND CHOCKS.



-23	-21	-19	-17		-13	-11	-9	-7	-5	-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL
							32	32	32	32	32	MS51968-9 17		HEX NUT	
							64	64	64	64	64	AN960-616 17		WASHER	
							32	32	32	32	32	17		SOC HD CAP SCR	STEEL-BLK OXIDE FIN
							2	2	2	2	2	-65	1 A6	STRAP	5456-H116/H117 AL ALY
1												18 -63	1	WEB	
2	2											-61	1	END PLATE	
1	1											-59	1	CAP	
	1											-57	1	WEB	
		2										18 -55	1 D8	FRAME	
		2										18 -53	1 D8	FRAME	
			2									-51	1 D8	FRAME	
			2									-49	1 D8	FRAME	
		4										18 -47	1 D10	CHOCK	
		4										18 -45	1 D10	CHOCK	
			8									-43	1 C8	CHOCK	
		1	1									-39	1 C9	PLATE	
					4							18 -35	1 D6	STRINGER	
						4						-31	1 D6	STRINGER	
					1							18 -29	1 D7	PLATE	
						1						-27	1 D7	PLATE	5456-H116/H117 AL ALY
							4	4	4	4	4	16 -25	1 A6	FRAME FITTING	6061-T6511 AL ALY
-								2	2			18 -23	1 A4	WELDMENT-HEAVY FRAME	
	-						2			2	2	-21	1 A4	WELDMENT-LIGHT FRAME	
		-						2	2			18 -19	1 B5	WELDMENT-HEAVY	END PLATE
			-				2			2	2	-17	1 B5	WELDMENT-LIGHT	END PLATE
					-			1	1			18 -13	1 C7	WELDMENT-HEAVY	PLATE
						-	1			1	1	-11	1 C7	WELDMENT-LIGHT	PLATE
							-					-9	1	ASSY-LIGHT PLATE	SINGLE BUCKLED
								-				18 -7	1 B7	ASSY-HEAVY PLATE	BUCKLED STRINGERS
									-			18 -5	1 B7	ASSY-HEAVY PLATE	PANEL ELEMENT
										-		-3	1 B7	ASSY-LIGHT PLATE	BUCKLED STRINGERS
											-	-1	1 B7	ASSY-LIGHT PLATE	PANEL ELEMENT

QUANTITY REQUIRED

PARTS LIST

ALL MACHINED SURFACES 250/ UNLESS OTHERWISE SPECIFIED.

-3	-1	PART NUMBER	CONF	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC.	PROCESS
32	32	MS51968-9 17		HEX NUT				
64	64	MS9(?)-616 17		WASHER				
32	32	17		SOC HD CAP SCR	STEEL-BLK OXIDE FIN	3/8 x 24 UNF x 2 1/4	COMMERCIAL	
2	2	-65	1	STRAP	5456-H116/H117 AL ALY	.250 x 2 x 108	QQ-A-250/20	
		18 -63	1	WEB		.275 x 11 5/16 x 41 3/8		14
		-61	1	END PLATE		.625 x 4 3/4 x 13 1/2		
		-59	1	CAP		.550 x 4 x 41 1/8		14
		-57	1	WEB		.275 x 11 5/16 x 41 3/8		14
		18 -55	1	FRAME		.375 x 1 x 10 3/4		
		18 -53	1	FRAME		.375 x 1 x 39 3/4		
		-51	1	FRAME		.250 x 1 x 11		
		-49	1	FRAME		.250 x 1 x 40		
		18 -47	1	CHOCK		.375 x 3 3/16 x 4		
		18 -45	1	CHOCK		.375 x 2 x 4		
		-43	1	CHOCK		.250 x 3 1/2 x 4		
		-39	1	PLATE		.500 x 12 x 41		
		18 -35	1	STRINGER		.375 x 5 1/8 x 108		
		-31	1	STRINGER		.250 x 4 x 108		
		18 -29	1	PLATE		.394 x 41 5/8 x 108		14
		-27	1	PLATE	5456-H116/H117 AL ALY	.200 x 41 5/8 x 108	QQ-A-250/20	
4	4	16 -25	1	FRAME FITTING	6061-T651 AL ALY	5 x 5 x 12 1/4	QQ-A-250/11	
		18 -23	1	WELDMENT-HEAVY FRAME				
2	2	-21	1	WELDMENT-LIGHT FRAME				
		18 -19	1	WELDMENT-HEAVY END PLATE				
2	2	-17	1	WELDMENT-LIGHT END PLATE				
		18 -15	1	WELDMENT-HEAVY PLATE				
1	1	-11	1	WELDMENT-LIGHT PLATE				
		-9	1	ASSY [illegible] PLATE - SINGLE BUCKLED STRINGER PANEL ELEMENT				
		18 -7	1	ASSY-HEAVY PLATE-BUCKLED STRINGERS PANEL ELEMENT				
		18 -5	1	ASSY-HEAVY PLATE PANEL ELEMENT				
—		-3	1	ASSY-LIGHT PLATE-BUCKLED STRINGERS PANEL ELEMENT				
	—	-1	1	ASSY-LIGHT PLATE PANEL ELEMENT				

PARTS LIST

ALL MACHINED SURFACES 250√ UNLESS OTHERWISE SPECIFIED.

TEST ARTICLE ASSEMBLY THREE-BAY PANEL ELEMENT, COMBINED LOADING TEST

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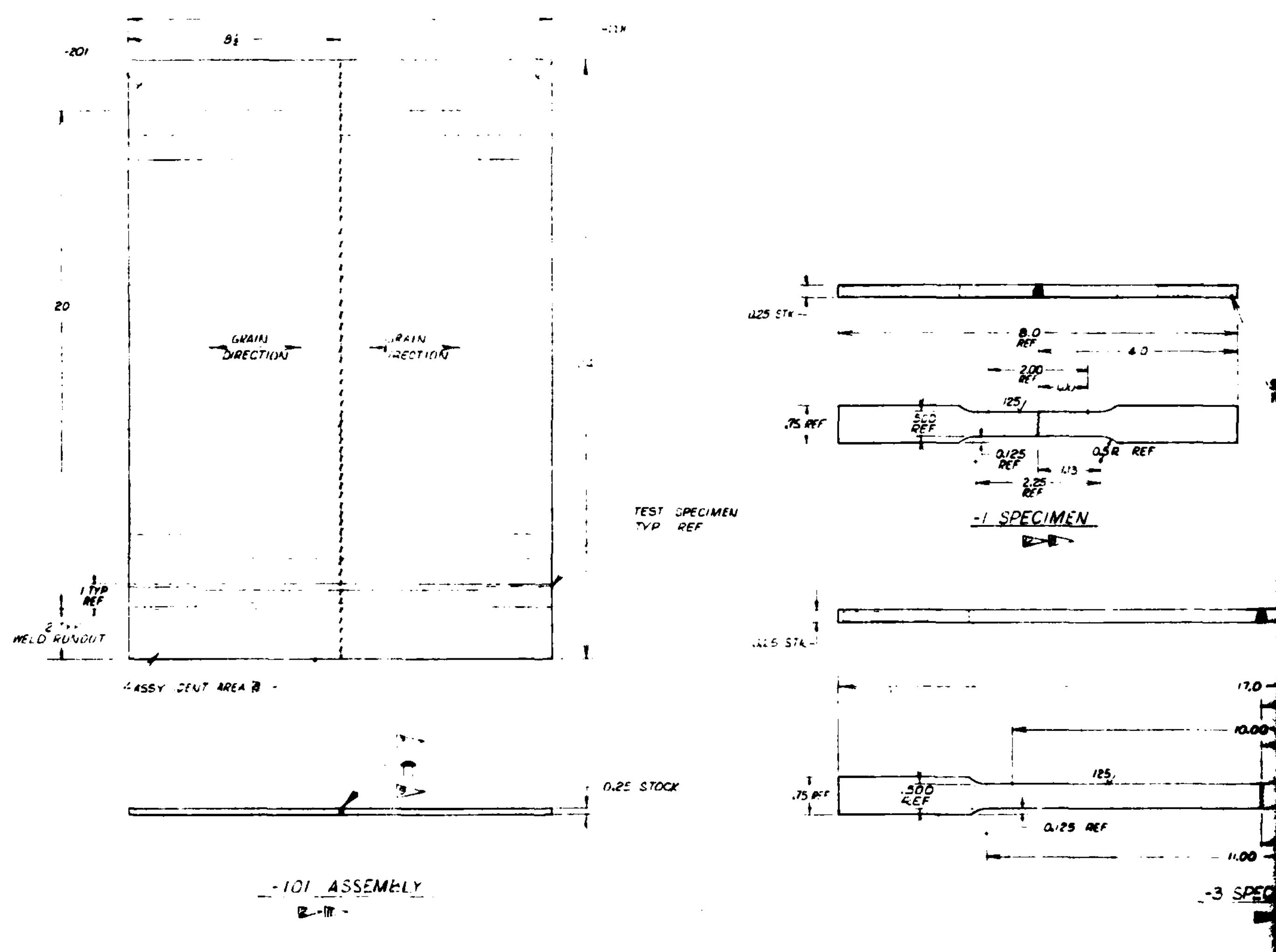
SCALE NOTED | SHEET 1 OF 1

[illegible]



-201
8½
20
GRAIN DIRECTION
GRAIN DIRECTION
1 TYP REF
WELD RUNOUT
ASSY IDENT AREA
0.25 STOCK
TEST SPECIMEN TYP REF
-101 ASSEMBLY
0.25 STK
8.0 REF
4.0
2.00 REF
.75 REF
.500 REF
125
0.125 REF
0.5R REF
1.13
2.25 REF
-1 SPECIMEN
17.0
10.00
.75 REF
.500 REF
125
0.125 REF
11.00
-3 SPEC

2

NOTES

1 BREAK ALL SHARP EDGES

2 UNLESS OTHERWISE SPECIFIED, ALL FABRICATION, WELDING, AND INSPECTION TO BE PER NAVSEA 0900-LP-060-4010.

3 WELD SYMBOLS PER AWS A2.4-76. WELDING TO BE ACCOMPLISHED USING PROCEDURES REPRESENTATIVE OF BASES PRODUCTION AND QUALIFIED PER MIL-STD-248.

4 WELD REPAIRS ARE NOT PERMITTED WITHOUT SPECIFIC STRUCTURES ENGINEERING APPROVAL

5 COGNIZANT STRUCTURES ENGINEER TO WITNESS WELDING.

6 SURFACE INSPECTION ACCEPTANCE CRITERIA FOR WELDS TO BE PER PARA 5.2 OF NAVSEA 0900-LP-003-8000 BASED ON 100% VISUAL INSPECTION BEFORE REMOVAL OF WELD REINFORCEMENTS

7 100% RADIOGRAPHIC INSPECTION OF WELDS TO BE PERFORMED PER MIL-STD-271. ACCEPTANCE CRITERIA TO BE PER NAVSEA 0900-LP-003-9000 (CLASS 3 MINIMUM.)

8 PERMANENTLY IDENTIFY EACH ASSEMBLY IN APPROX LOCATION SHOWN USING CHARACTERS 1/16" HIGH. EG. DWG NO. - DASH NO - SERIAL NO

9 REMOVE FRONT AND BACK FACE WELD BEAD REINFORCEMENTS FLUSH TO MATERIAL SURFACE.

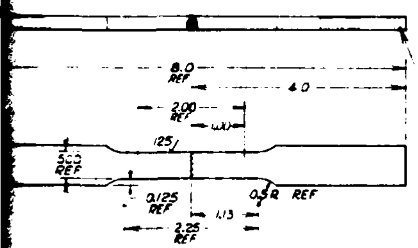
10 PERMANENTLY IDENTIFY EACH END OF SPECIMEN IN APPROX LOCATION SHOWN USING CHARACTERS 3/16" HIGH. EG DWG.NO.- DASH NO.- REPLICATE NO.

11 RMI RESPONSIBLE FOR PRODUCTION INSPECTION. AND ACCEPTANCE OF -101 ASSY'S.

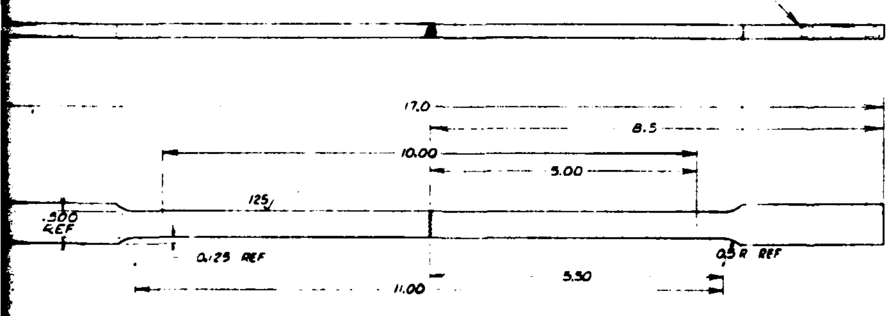
12 ROHR INDUSTRIES ENGINEERING TEST LAB TO CUT SPECIMEN BLANKS AND TRIM TO FINAL SIZES SPECIFIED ON F/D. LAYOUT OF SPECIMENS ON -101 ASSY'S TO BE COORDINATED WITH COGNIZANT RMI STRUCTURES ENGINEER.

13 EXCEPT WHERE NOTED, TRIM AND MACHINE IN ACCORDANCE WITH STANDARD SPECIMEN, SHEET TYPE, PER ASTM E8-74 FIGURE 6

14 TOTAL QUANTITIES REQUIRED: -1 24 EA
-3 24 EA.
-101 4 EA.



-1 SPECIMEN



-3 SPECIMEN

			-101			-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATL SIZE
			2					-201		PLATE	5456 H116/H117 AL ALY	.250 x
			—					-101		WELD ASSEMBLY		
						—		-3		SPECIMEN - 10" GL	MF -101 ASSY	
							—	-1		SPECIMEN - 2" GL	MF -101 ASSY	

QUANTITY REQ'D PER ASSY

P A R T S L I S T

3

…N, WELDING, AND INSPECTION

…S TO BE ACCOMPLISHED USING
…CTION AND QUALIFIED

…CIFIC STRUCTURES

…SS WELDING.

… WELDS TO BE PER PARA 5.2 OF
… VISUAL INSPECTION BEFORE

… BE PERFORMED PER
… PER NAVSEA 0900-LP-003-3000 (CLASS

… APPROX LOCATION SHOWN USING
…IAL NO.

…EINFORCEMENTS FLUSH TO MATERIAL SURFACE.

…N IN APPROX LOCATION SHOWN USING
…PLICATE NO.

…TION, AND ACCEPTANCE OF -101 ASSY'S.

… CUT SPECIMEN BLANKS AND TRIM TO
…OF SPECIMENS ON -101 ASSY'S TO BE
…CTURES ENGINEER.

… IN ACCORDANCE WITH STANDARD
… FIGURE 6

-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC.	PROCESS
		-201		PLATE	5456 H116/H117 AL ALY	.250 x 8½ x 24	QQ-A-250/20	
		-101		WELD ASSEMBLY				▷
—		-3		SPECIMEN - 10" GL	MF -101 ASSY			
	—	-1		SPECIMEN - 2" GL	MF -101 ASSY			

P A R T S   L I S T

WELDED PLATE
ASSY / SPECIMENS
DYNAMIC STRENGTH TESTS

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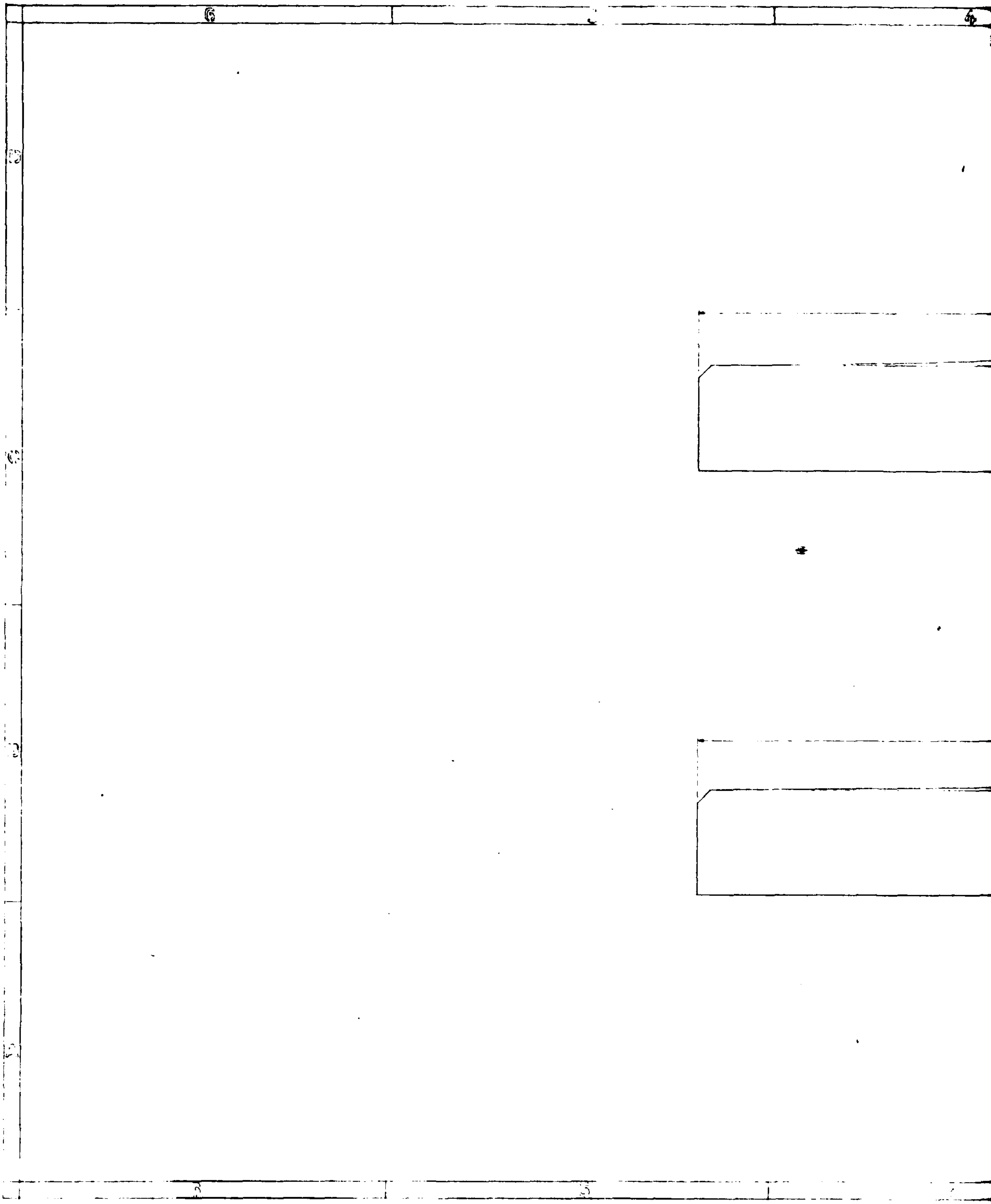
SHEET 1 OF 1



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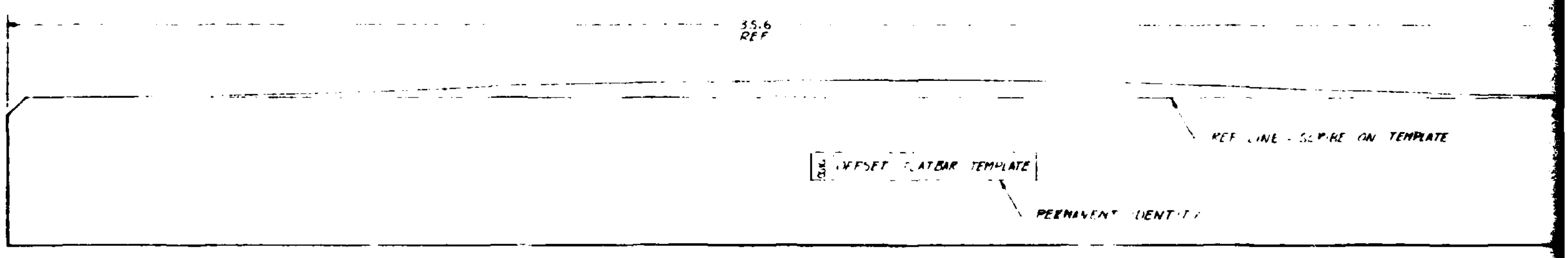
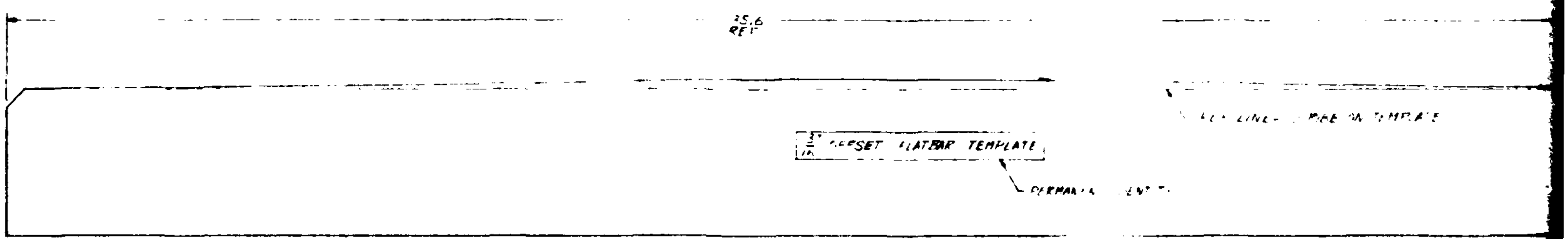
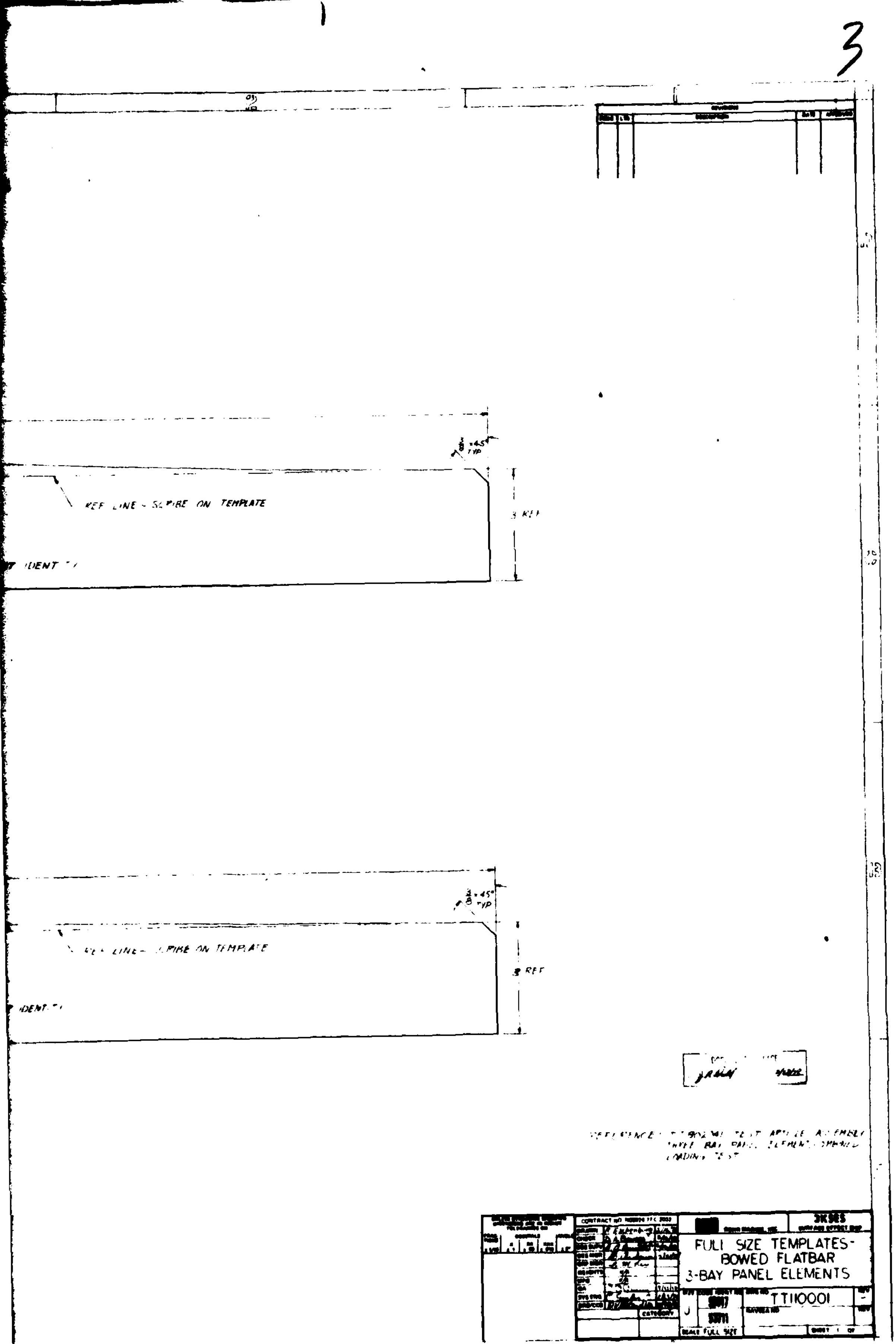
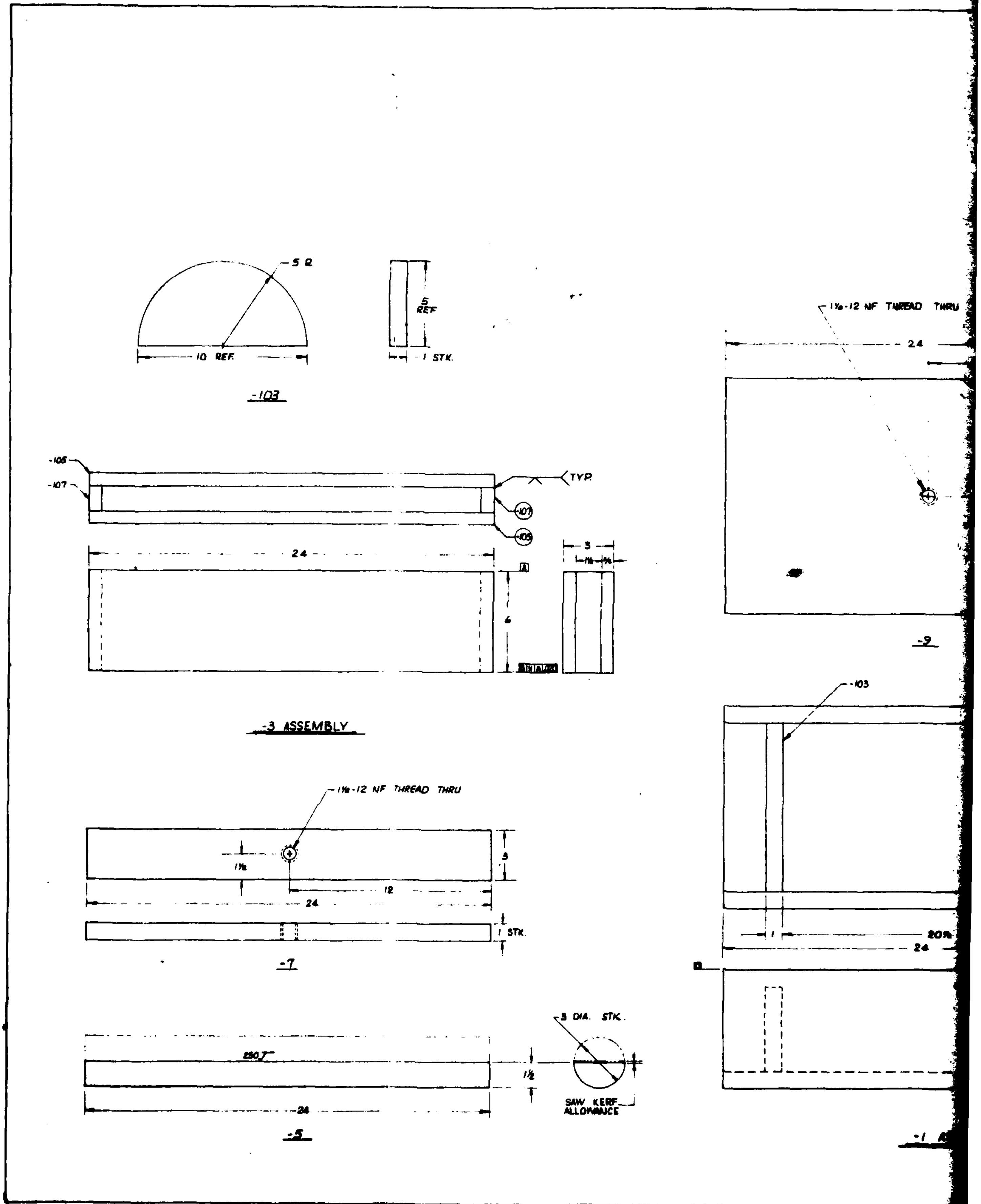


1 3-BAY FLATBAR STIFFENED PANEL
BOWED FLATBAR FULL SIZE TEMPLATE
MAKE FROM ANY ALUM SHEET BETWEEN .063 AND .125 THICK OR PLASTIC BETWEEN 1/8 AND 1/4 THICK



2 3-BAY FLATBAR STIFFENED PANEL
BOWED FLATBAR FULL SIZE TEMPLATE
MAKE FROM ANY ALUM SHEET BETWEEN .063 AND .125 THICK OR PLASTIC BETWEEN 1/8 AND 1/4 THICK.


REF LINE - SCRIBE ON TEMPLATE
3 REF
FULL SIZE TEMPLATES-
BOWED FLATBAR
3-BAY PANEL ELEMENTS
TT110001
SCALE FULL SIZE

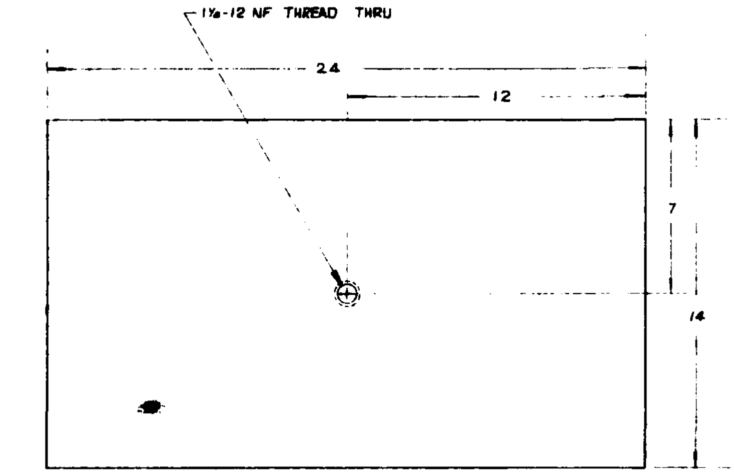


5 R
10 REF.
5 REF
1 STK.
-103
-105
-107
TYP.
107
105
24
3
1½
¾
A
6
-3 ASSEMBLY
1⅛-12 NF THREAD THRU
1½
3
12
24
1 STK.
-7
3 DIA. STK.
250
1½
24
SAW KERF ALLOWANCE
-5
1⅛-12 NF THREAD THRU
24
-9
-103
1
20½
24
-1

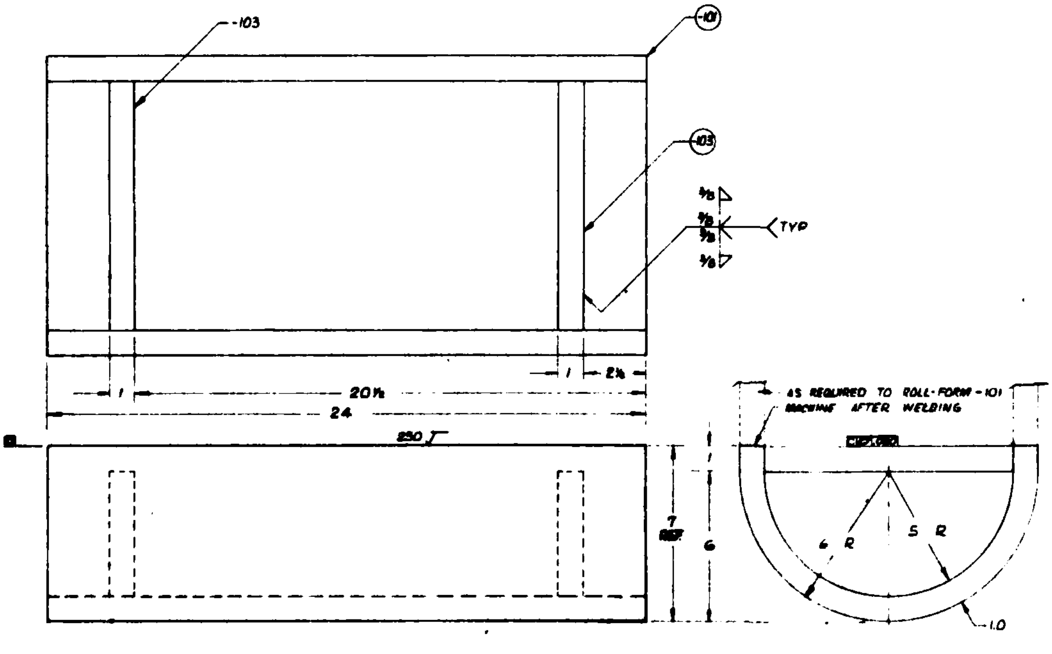
2 1

NOTES:

1. BREAK ALL SHARP EDGES .005 MIN R
2. ALL ALUMINUM FABRICATION, WELDING AND INSPECTION TO BE PER NAVSEA 0900-LP-060-4010.
3. WELD SYMBOLS PER AWS A2.4-76. WELDING TO BE ACCOMPLISHED USING PROCEDURES REPRESENTATIVE OF 3KSES PRODUCTION
4. SURFACE INSPECTION ACCEPTANCE CRITERIA FOR WELDS TO BE PER PARA 5.2 OF NAVSEA 0900-LP-003-8000 BASED ON 100% VISUAL INSPECTION.
5. QUANTITIES REQUIRED: -1 ASSY 1 EA.
   -3 ASSY 1 EA.
   -5 KEEL 1 EA.
   -7 BRG PL 1 EA.
   -9 BRG PL 1 EA.
6. THIS DRAWING DEFINES THE TEST KEEL ASSEMBLIES AND COMPONENTS NEEDED TO PERFORM PRELIMINARY 3KSES DRY DOCKING CAP BLOCK LOADING TESTS INITIATED BY HULL STRUCTURES ENGINEERING AND APPROVED BY THE DEPUTY PROGRAM MANAGER.
7. OPTIONAL MATERIAL FOR -101 AND -103 IS AL. ALY 6061. IF THIS OPTION IS SELECTED, THE WELDED -1 ASSY SHALL BE HEAT TREATED TO THE T6 TEMPER CONDITION.



-9



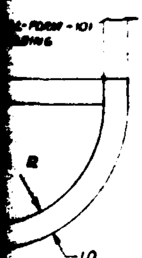
-1 ASSEMBLY

	2		-107		PLATE	5456-H116/H117 AL
	2		-105		PLATE	
		2	-103		FORMER	
		1	-101		PLATE	5456-H116/H117 AL
			-9		BEARING PL	5456-H116/H117 AL
			-7		BEARING PL	5456-H116/H117 AL
			-5		FWD KEEL	6061-T6 AL ALY
	–		-3		SPACER ASSY	
		–	-1		AFT KEEL ASSY	
QUAN / ASSY	-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL

P A R T S

3

ALL SHARP EDGES .005 MIN R
[illegible]UM FABRICATION, WELDING AND INSPECTION TO BE PER
0900-LP-050-4010.
SYMBOLS PER AWS A2.4-76 WELDING TO BE ACCOMPLISHED
PROCEDURES REPRESENTATIVE OF 3KSES PRODUCTION
INSPECTION ACCEPTANCE CRITERIA FOR WELDS TO BE PER
.2 OF NAVSEA 0900-LP-003-8000 BASED ON 100%
INSPECTION.
[illegible]TIES REQUIRED: -1 ASSY 1 EA.
-3 ASSY 1 EA.
-5 KEEL 1 EA.
-7 BRG PL 1 EA.
-9 BRG PL 1 EA.
[illegible]AWING DEFINES THE TEST KEEL ASSEMBLIES AND COMPONENTS
TO PERFORM PRELIMINARY 3KSES DRY DOCKING CAP BLOCK
[illegible] TESTS INITIATED BY HULL STRUCTURES ENGINEERING AND
[illegible]ED BY THE DEPUTY PROGRAM MANAGER.
[illegible]AL MATERIAL FOR -101 AND -103 IS AL ALY 6061. IF THIS
IS SELECTED, THE WELDED -1 ASSY SHALL BE HEAT
[illegible]ED TO THE T6 TEMPER CONDITION.



	2		-107		PLATE	5456-H116/H117 AL ALY	3/16 × 1 1/2 × 6	QQ-A-250/20	
	2		-105		PLATE	↓	3/16 × 6 × 24	↓	
		2	-103		FORMER	↓	1 × 5 × 10	↓	
		1	-101		PLATE	5456-H116/H117 AL ALY	1 × 24 × A/REQD	QQ-A-250/20	
			-9		BEARING PL	5456-H116/H117 AL ALY	1 × 14 × 24	QQ-A-250/20	
			-7		BEARING PL	5456-H116/H117 AL ALY	1 × 3 × 24	QQ-A-250/20	
			-5		FWD KEEL	6061-T6 AL ALY	3 DIA × 24 LG.	COM'L	
	–		-3		SPACER ASSY				
		–	-1		AFT KEEL ASSY				
QUAN / ASSY	-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC.	PROCESS

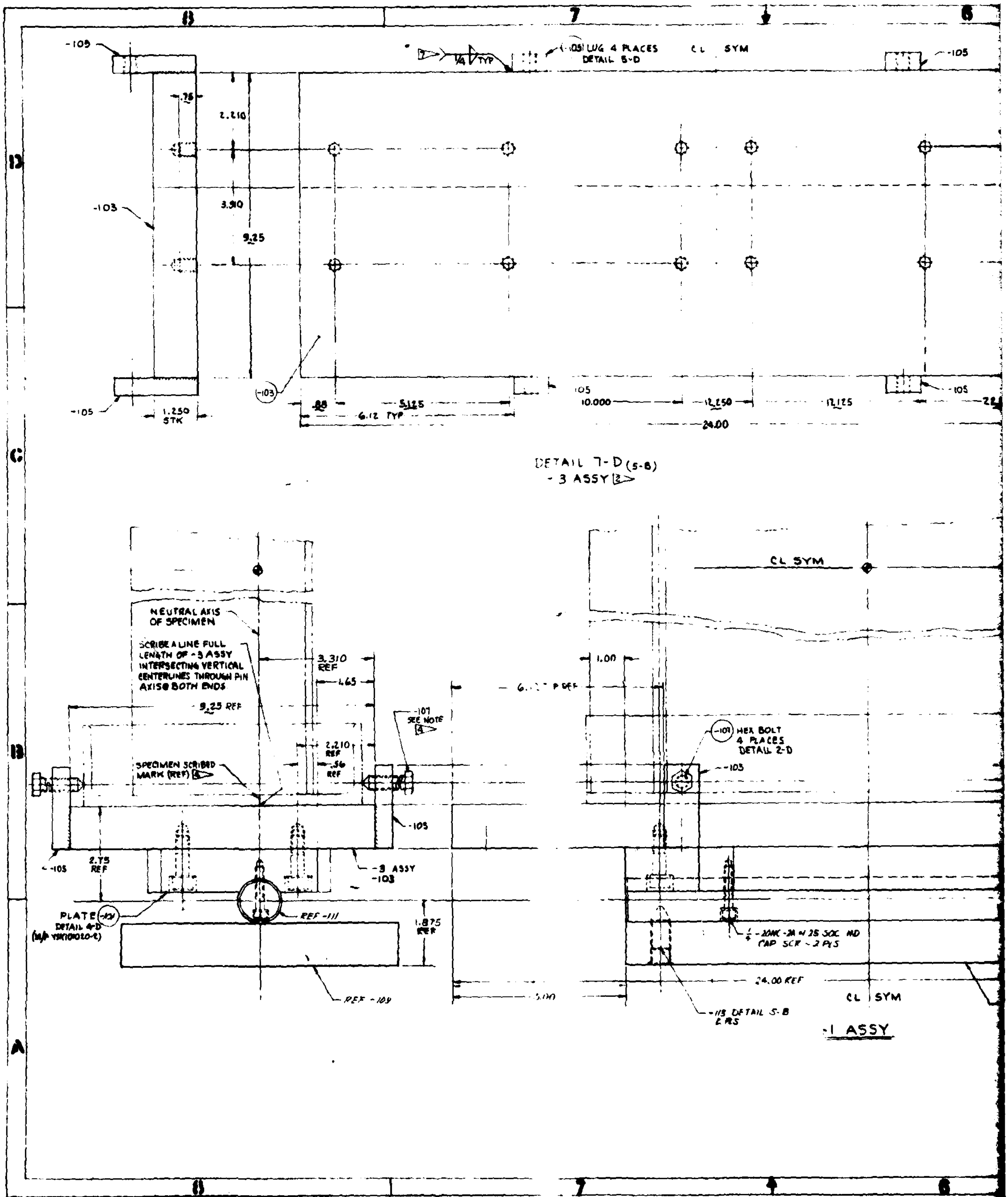
PARTS LIST

3KSES

KEEL ASSEMBLIES
CAP BLOCK LOADING TESTS
3KSES DRYDOCKING

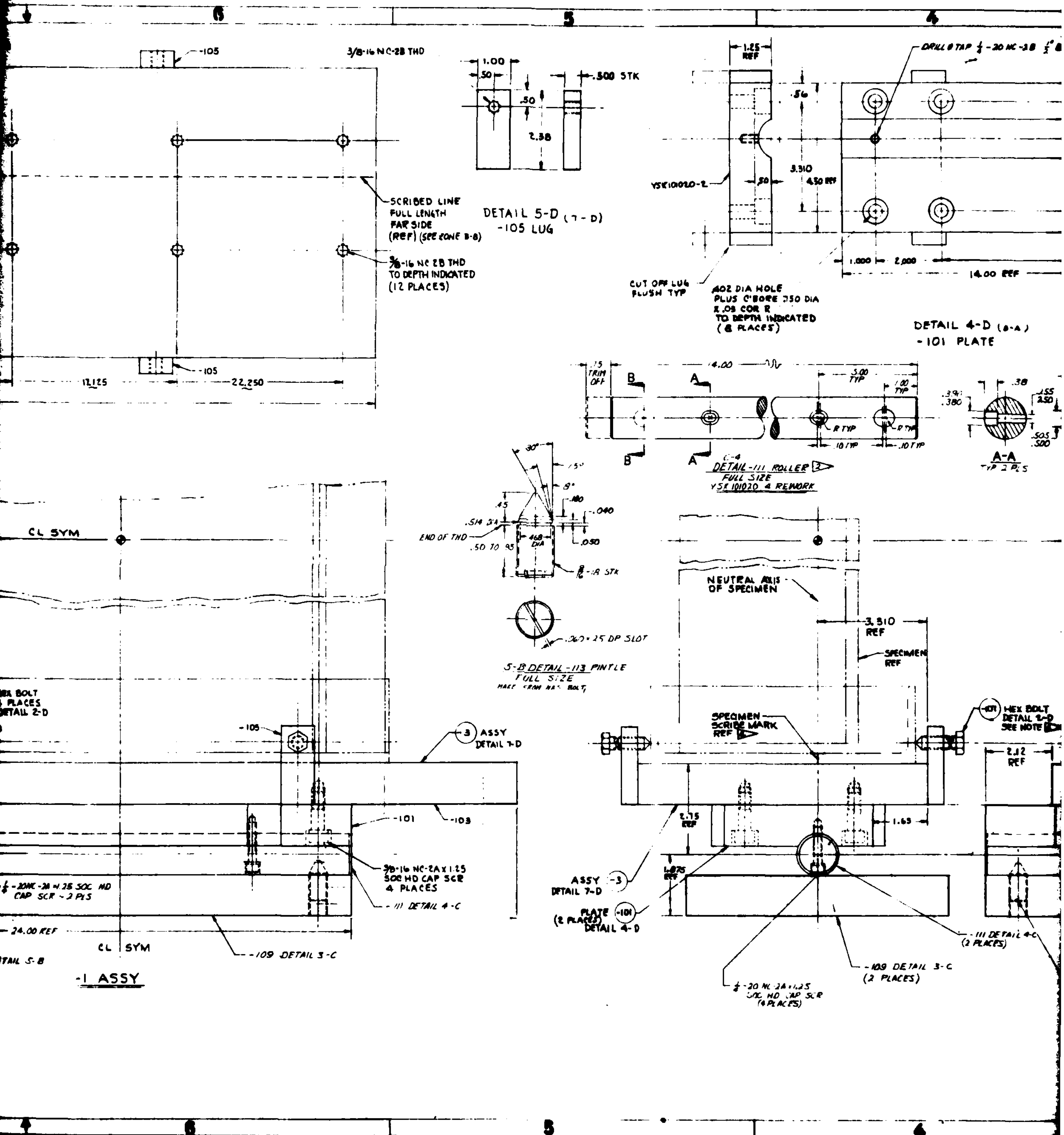
SIZE J | 59717 | TT 801100
59711

A TORRES

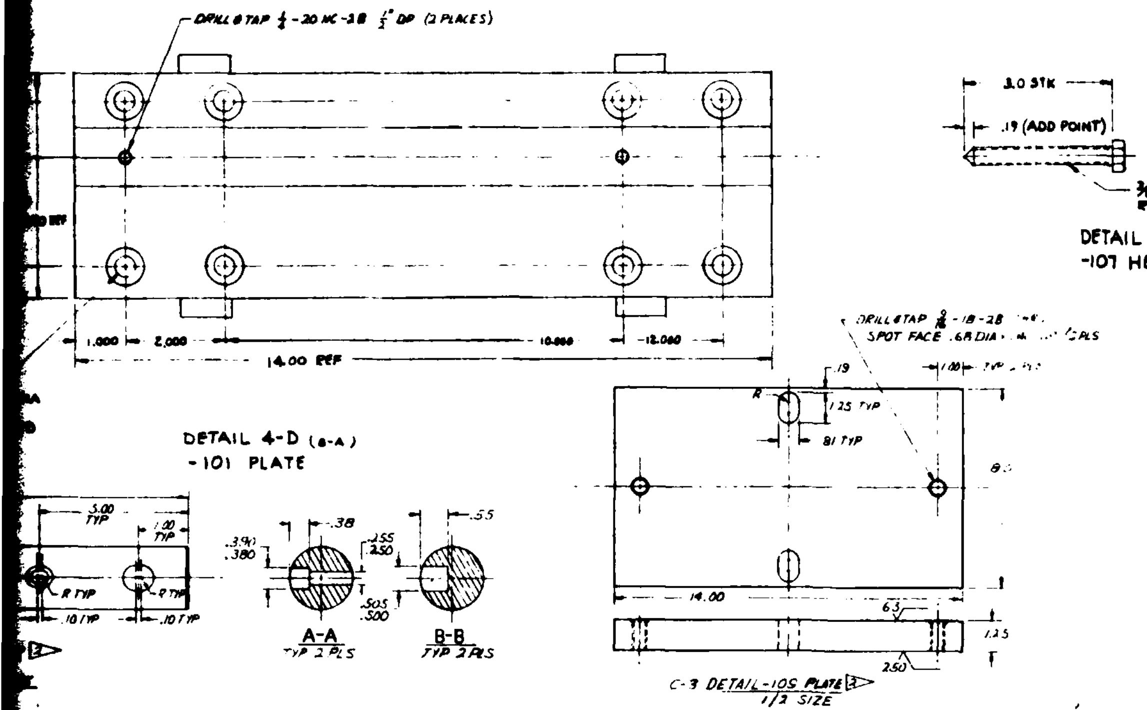


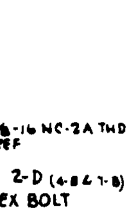
8
7
6
D
C
B
A
-105
-103
-105
1.250 STK
2.210
3.910
9.25
.75
.88
5.125
6.12 TYP
1/4 TYP
-105 LUG 4 PLACES DETAIL 5-D
CL SYM
-105
10.000
12.250
17.125
24.00
DETAIL 7-D (5-B)
-3 ASSY
NEUTRAL AXIS OF SPECIMEN
SCRIBE A LINE FULL LENGTH OF -3 ASSY INTERSECTING VERTICAL CENTERLINES THROUGH PIN AXIS @ BOTH ENDS
3.310 REF
1.65
9.25 REF
2.210 REF
.56 REF
-107 SEE NOTE 4
SPECIMEN SCRIBED MARK (REF)
-105
-105
2.75 REF
-3 ASSY -103
PLATE -101 DETAIL 4-D
REF -111
1.875 REF
REF -109
CL SYM
1.00
-107 HEX BOLT 4 PLACES DETAIL 2-D
-103
1/4 -20NC -2A x 2.25 SOC HD CAP SCR - 2 PLS
24.00 REF
5.00
-113 DETAIL 5-B 2 PLS
CL SYM
-1 ASSY

21

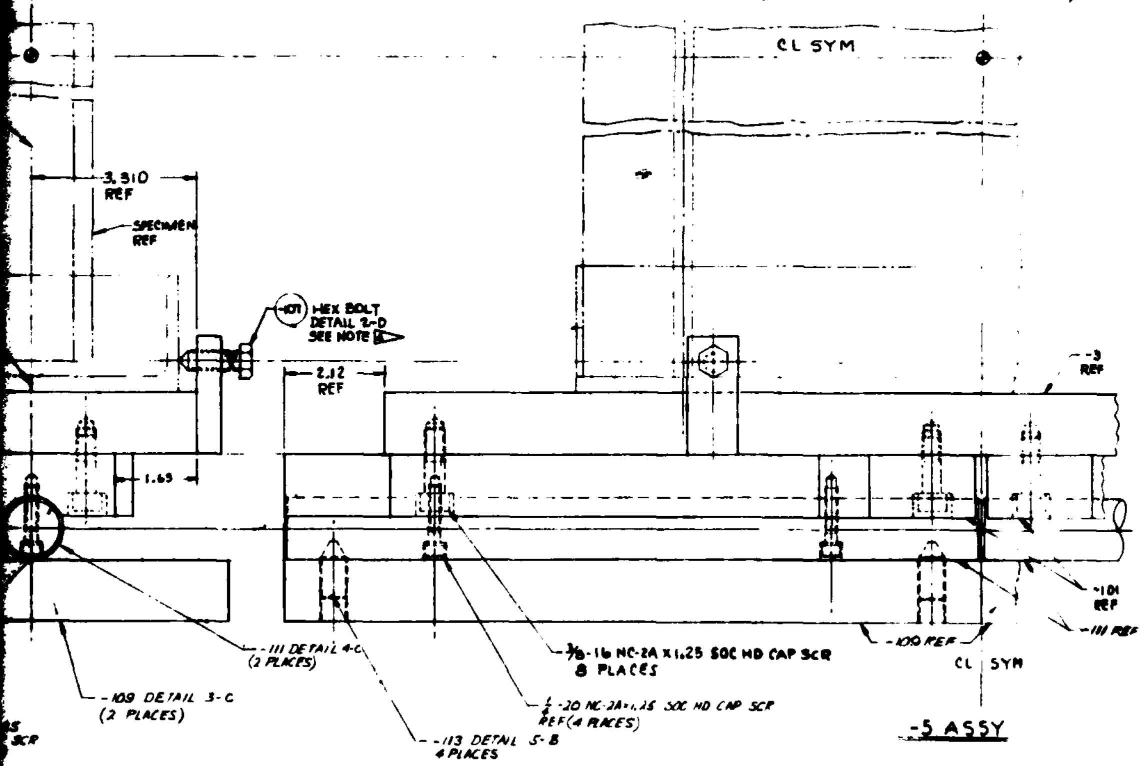


-105
3/8-16 NC-2B THD
SCRIBED LINE FULL LENGTH FAR SIDE (REF) (SEE ZONE 8-B)
3/8-16 NC 2B THD TO DEPTH INDICATED (12 PLACES)
12.125
22.250
1.00
.50
.50
.500 STK
2.38
DETAIL 5-D (7-D)
-105 LUG
1.25 REF
.56
3.310
4.50 REF
YSK101020-2
CUT OFF LUG FLUSH TYP
.402 DIA HOLE PLUS C'BORE .750 DIA X .05 COR R TO DEPTH INDICATED (8 PLACES)
1.000
2.000
14.00 REF
DETAIL 4-D (8-A)
-101 PLATE
14.00
B
A
DETAIL -111 ROLLER
FULL SIZE
YSK 101020 4 REWORK
A-A
TYP 2 PLS
CL SYM
END OF THD
5-B DETAIL -113 PINTLE
FULL SIZE
NEUTRAL AXIS OF SPECIMEN
3.310 REF
SPECIMEN REF
SPECIMEN SCRIBE MARK REF
HEX BOLT DETAIL 2-D
-3 ASSY DETAIL 7-D
-101
-103
3/8-16 NC-2A X 1.25 SOC HD CAP SCR 4 PLACES
-111 DETAIL 4-C
24.00 REF
CL SYM
-109 DETAIL 3-C
-1 ASSY
ASSY -3 DETAIL 7-D
PLATE -101 (2 PLACES) DETAIL 4-D
1.65
2.12 REF
-111 DETAIL 4-C (2 PLACES)
-109 DETAIL 3-C (2 PLACES)
1/4-20 NC-2A X 1.25 SOC HD CAP SCR (4 PLACES)





NOTES:
1. BREAK ALL SHARP EDGES
2. FINISH: BLACK OXIDE PER MIL-C-13924A
3. ALL MACHINED SURFACES 250/.
4. ALIGN TEST SPECIMEN SCRIBE MARKS TO SCRIBE LINE ON -3 SPECIMEN END CAP CHANNELS APPROX 0.03 DEEP
5. HEAT TREAT BEFORE FINAL SURFACE MACHINING TO
6. AT INSTALLATION, ALIGN THE UPPER AND LOWER BASE AS REQUIRED TO ACHIEVE UNIFORM PIN BEARING LOADING.
7. GAS TUNGSTEN ARC WELD USING 17-22 WELD WIRE PER CRACKS PERMITTED.
8. WALDES TRUARC P/N 5108-50 OR EQUIVALENT



-5	-3	-1	PART NUMBER	DESCRIPTION
~~4~~		~~2~~	~~YSK101020-4~~	~~PIN~~
~~4~~		~~2~~	~~YSK101020-3~~	~~BASE PLATE~~
16		8		SOC HEAD CAP SCR
8		8	-107	HEX BOLT
	4		-105	LUG
	1		-103	CRADLE PLATE
4		2	-101	PLATE
8		4		RETAINING RING
8		4		SOC HD CAP SCR
8		4	-113	PINTLE
4		2	-111	PIN
4		2	-109	BEARING PLATE
-			-5	ASSY
2	-	2	-3	CRADLE ASSY
		-	-1	ASSY

QUAN REQD PER NOTED DASH NO.

PARTS LIST

4

			CHANGE		
		A	INCORPORATED E.C.R. 701063		

...C-2A THD

...(4-8 4 1-8)
...AT

NOTES:
1. BREAK ALL SHARP EDGES
2. FINISH: BLACK OXIDE PER MIL-C-13924A
3. ALL MACHINED SURFACES 250/.
4. ALIGN TEST SPECIMEN SCRIBE MARKS TO SCRIBE LINE ON -3 ASSY, WITHIN ± .020. TIGHTEN -107 BOLTS TO SET POINTS INTO SPECIMEN END CAP CHANNELS APPROX 0.03 DEEP.
5. HEAT TREAT BEFORE FINAL SURFACE MACHINING TO 180 KSI MIN 200 KSI MAX TENSILE STRENGTH PER MIL-H-6875
6. AT INSTALLATION, ALIGN THE UPPER AND LOWER BASE PLATES (YSK101020-3), USING THE YSK101020-4 PINS & SHIMS AS REQUIRED TO ACHIEVE UNIFORM PIN BEARING LOADING.
7. GAS TUNGSTEN ARC WELD USING 17-22 WELD WIRE PER AMS 6458. VISUAL INSPECT ONLY. NO VISIBLE CRACKS PERMITTED.
8. WALDES TRUARC P/N 5108-50 OR EQUIVALENT

-5	-3	-1	PART NUMBER	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
~~4~~		~~2~~	~~YSK101020-4~~	~~PIN~~				
~~4~~		~~2~~	~~YSK101020-3~~	~~BASE PLATE~~				
16		8		SOC HEAD CAP SCR	STL BLK OXIDE FIN	3/8-16 NC 2A x 1.25 LG	COML	
8		8	-107	HEX BOLT	M/F STL-CAD PL	3/8-16 NC 2A FULL THD x 3.0	COM'L	
	4		-105	LUG	E4130 HRN	1/2 x 1.00 x 2.38 BAR	MIL-S-18729	
	1		-103	CRADLE PLATE	E4130 HRN	1 1/4 x 9.25 x 24.0 PL	MIL-S-18729	
4		2	-101	PLATE	M/F YSK101020-2	CRADLE ASSY		
8		4		RETAINING RING	STL	1/2 EXT INVERTED		8
8		4		SOC HD CAP SCR	STL	1/4-20 NC 2A x 1.25 LG	COML	
8		4	-113	PINTLE	M/F 5/16 NAS BOLT			
4		2	-111	PIN	M/F YSK101020-4			2
4		2	-109	BEARING PLATE	E 4340 HRN	1 1/4 x 8 x 14 PL	MIL-S-5000	5 3
-			-5	ASSY				
2	-	2	-3	CRADLE ASSY				7
		-	-1	ASSY				
QTY REQD PER NOTED DASH NO.								

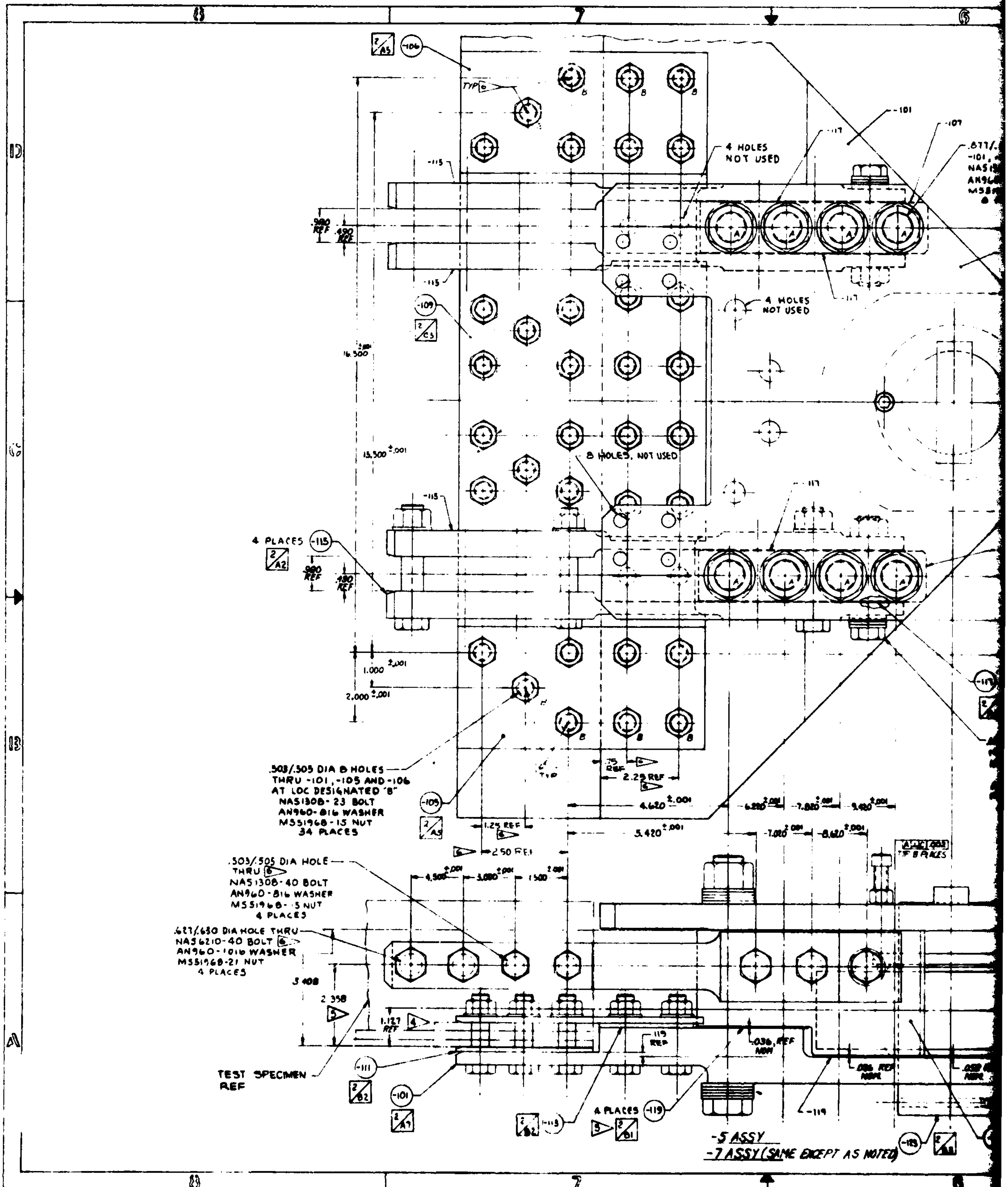
PARTS LIST

TT 802014 A

TEST FIXTURE & INSTL - COMPRESSION (MOD)

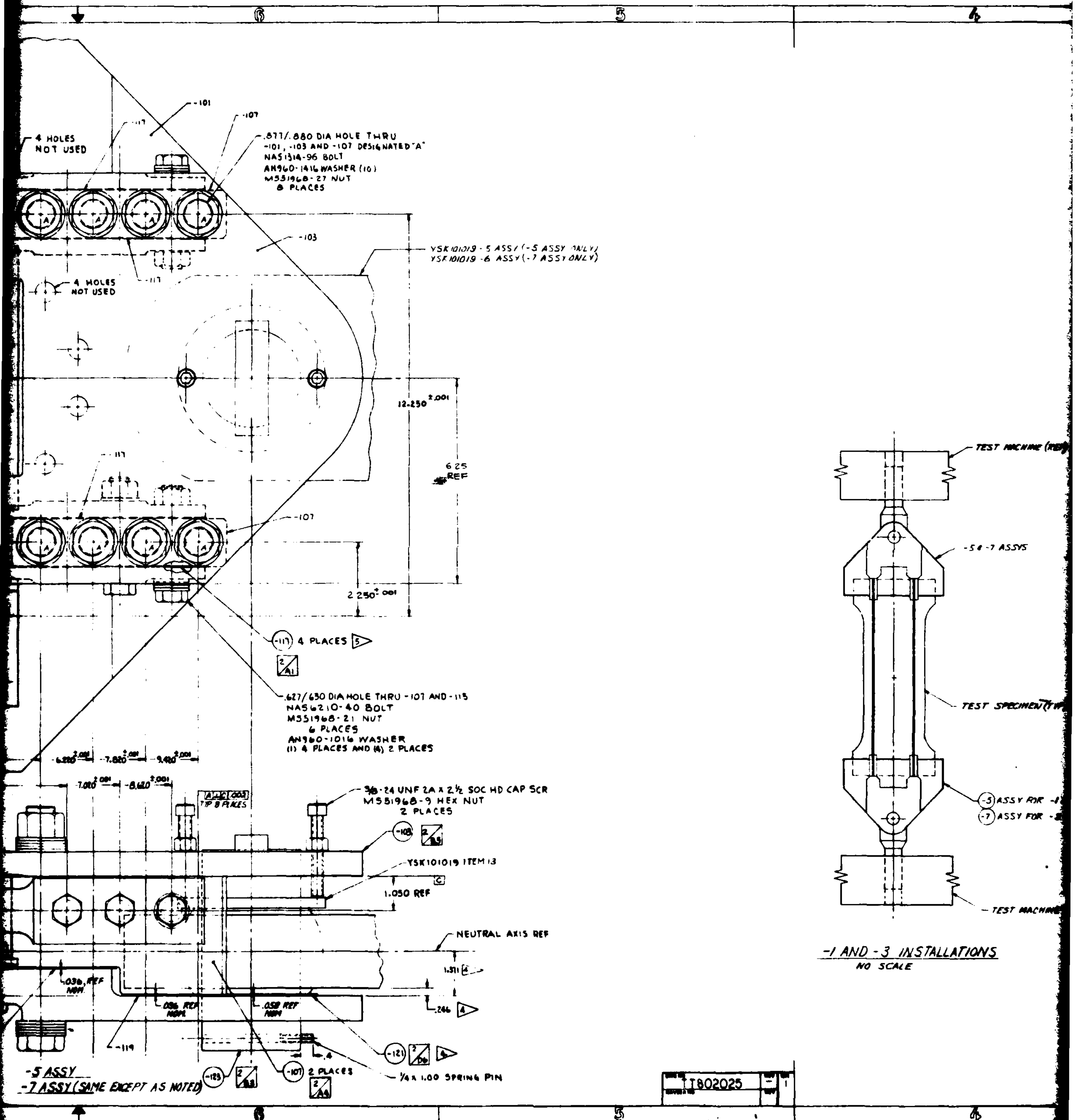
TT 802014

R.A. NICHOLS



4 HOLES
NOT USED
4 HOLES
NOT USED
8 HOLES, NOT USED
4 PLACES
.503/.505 DIA B HOLES
THRU -101, -105 AND -106
AT LOC DESIGNATED "B"
NAS1308-23 BOLT
AN960-816 WASHER
MS51968-15 NUT
34 PLACES
.503/.505 DIA HOLE
THRU
NAS1308-40 BOLT
AN960-816 WASHER
MS51968-15 NUT
4 PLACES
.627/.630 DIA HOLE THRU
NAS6210-40 BOLT
AN960-1016 WASHER
MS51968-21 NUT
4 PLACES
TEST SPECIMEN
REF
4 PLACES
-5 ASSY
-7 ASSY (SAME EXCEPT AS NOTED)

2 1



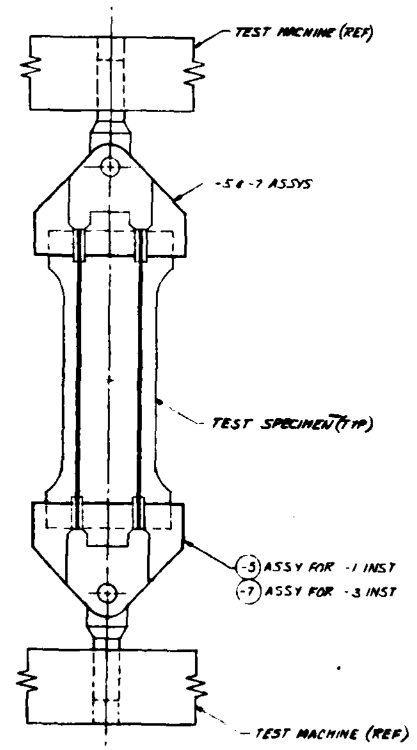
6
5
4
-101
-107
-117
4 HOLES NOT USED
.877/.880 DIA HOLE THRU
-101, -103 AND -107 DESIGNATED "A"
NAS1314-96 BOLT
AN960-1416 WASHER (10)
MS51968-27 NUT
8 PLACES
-103
YSK101019-5 ASSY (-5 ASSY ONLY)
YSK101019-6 ASSY (-7 ASSY ONLY)
4 HOLES NOT USED
12.250 ±.001
6.25 REF
2.250 ±.001
(-117) 4 PLACES 5
.627/.630 DIA HOLE THRU -107 AND -115
NAS6210-40 BOLT
MS51968-21 NUT
6 PLACES
AN960-1016 WASHER
(1) 4 PLACES AND (4) 2 PLACES
-6.220 ±.001
-7.820 ±.001
-9.420 ±.001
-7.020 ±.001
-8.620 ±.001
TYP 8 PLACES
3/8-24 UNF 2A x 2½ SOC HD CAP SCR
MS51968-9 HEX NUT
2 PLACES
(-105)
YSK101019 ITEM 13
1.050 REF
NEUTRAL AXIS REF
.036 REF NOM
.036 REF NOM
.058 REF NOM
1.311
.246
-119
(-121)
(-123)
(-107) 2 PLACES
1/4 x 1.00 SPRING PIN
-5 ASSY
-7 ASSY (SAME EXCEPT AS NOTED)
TEST MACHINE (REF)
-5 & -7 ASSYS
TEST SPECIMEN (TYP)
(-5) ASSY FOR -1
(-7) ASSY FOR -3
TEST MACHINE
-1 AND -3 INSTALLATIONS
NO SCALE
T802025
1

3 1 1

4	3	2

NOTES

1. BREAK SHARP EDGES .015R MAX
2. ABBREVIATIONS PER MIL-STD-12.
3. MACHINED SURFACES 125 UNLESS OTHERWISE SPECIFIED.
4. TEST LABORATORY TO REMOVE LAMINATIONS FROM -117 AND -121 SHIMS AS DIRECTED TO MATCH INDIVIDUAL TEST SPECIMEN NEUTRAL AXIS LOCATIONS DEFINED BY COGNIZANT STRUCTURES ENGINEER.
5. USE -119 SHIMS AS REQ'D TO OBTAIN PROPER FIT BETWEEN -101 AND -107.
6. THE HOLES IN -115 AS INSTALLED, AND THOSE INDICATED 'B' MUST BE COORDINATED WITH THE HOLE PATTERN IN THE EXISTING YSK101019 ITEMS 4 AND 35 AND MUST CONTINUE TO PROVIDE INTERCHANGEABILITY OF MATING TEST SPECIMENS AMONG THE -5 AND -7 ASSEMBLIES AND THE TT802029-1 (REF) SPECIMEN DRILL FIXTURE.
7. EQUIVALENT MATERIALS MAY BE SUBSTITUTED WITH PRIOR APPROVAL OF COGNIZANT ROHR MARINE DESIGN ENGINEER
8. HEAT TREAT TO 180 KSI MIN, 200 KSI MAX TENSILE STRENGTH PER MIL-H-6875 PRIOR TO FINISH MACHINING.
9. FINISH: BLACK OXIDE PER MIL-C-13924A (CLASS 1)
10. (ENGINEERING REFERENCE). THE FIXTURES DEFINED ON THIS DWG ARE MAJOR MODIFICATIONS OF THE YSK101019A-1 & -2 FIXTURE INSTALLATIONS PRODUCED FOR THE H-5 ADP TESTS. THESE MODIFICATIONS ACCOMMODATE THE INCREASE IN STIFFENER SPACING FROM 8 TO 10 IN, PROVIDE FLEXIBILITY TO ACCEPT VARIOUS TEE & FLAT BAR STIFFENER CONFIGURATIONS & PROVIDE HIGHER LOAD CAPACITY FOR THE LARGER SPECIMENS REPRESENTATIVE OF THE 3KSES SCANTLINGS.



-1 AND -3 INSTALLATIONS
NO SCALE

		REF	REF			TT802029-1		DRILL F
		4	4			NAS1308-40	1 B6	HEX
		34	34			NAS1308-23	1 B6	HEX
		38	38			AN960-816	1 A6	WASH
		38	38			MS51968-15	1 A6	HEX
		8	8			MS51968-21	1 B6	HEX
		80	80			AN960-1416	1 D6	WAS
		8	8			NAS1314-96	1 B6	HEX
		16	16			AN960-1016	1 B6	WAS
		10	10			MS51968-21	1 B6	HEX
		10	10			NAS6210-40	1 B6	HEX
		2	2			MS51968-9	1 B6	HEX
		2	2				1 B6	SOC H
		1	1				1 A7	PIN,
			1			YSK101018-6 ASSY	1 D6	ROD
1						YSK101019 ITEM 9	2 B6	PIN
		1	1			YSK101019 ITEM 13	1 A6	RING
		1				YSK101019-5 ASSY	1 D6	ROD
1						-125	2 B3	LUG
—		1	1			-123	1 A6	PIN
		1	1			-121	1 A6	SHIM
		4	4			-119	1 A7	SHIM
		4	4			-117	1 B6	SHIM
		4	4			-115	1 C6	BAR
		1	1			-113	1 A7	SPA
		1	1			-111	1 A6	SPA
		1	1			-109	1 C7	PLA
		2	2			-107	1 A6	PLA
		1	1			-106	1 D7	PLA
		1	1			-105	1 B7	PLA
		1	1			-103	1 B6	PLA
		1	1			-101	1 A7	PLA
		—		2		-7	1 A7	ASS
			—		2	-5	1 A7	ASS
				—		-3	1 A4	A
					—	-1	1 A4	INS
-03		-7	-5	-3	-1	PART NUMBER	ZONE	DE
QUANTITY REQUIRED								

DOCUMENT RELEASE

4	3	2

1

4

2

ON THIS
18 -2
TESTS.
STIFFENER
PT VARIOUS
HIGHER
SENTATIVE OF

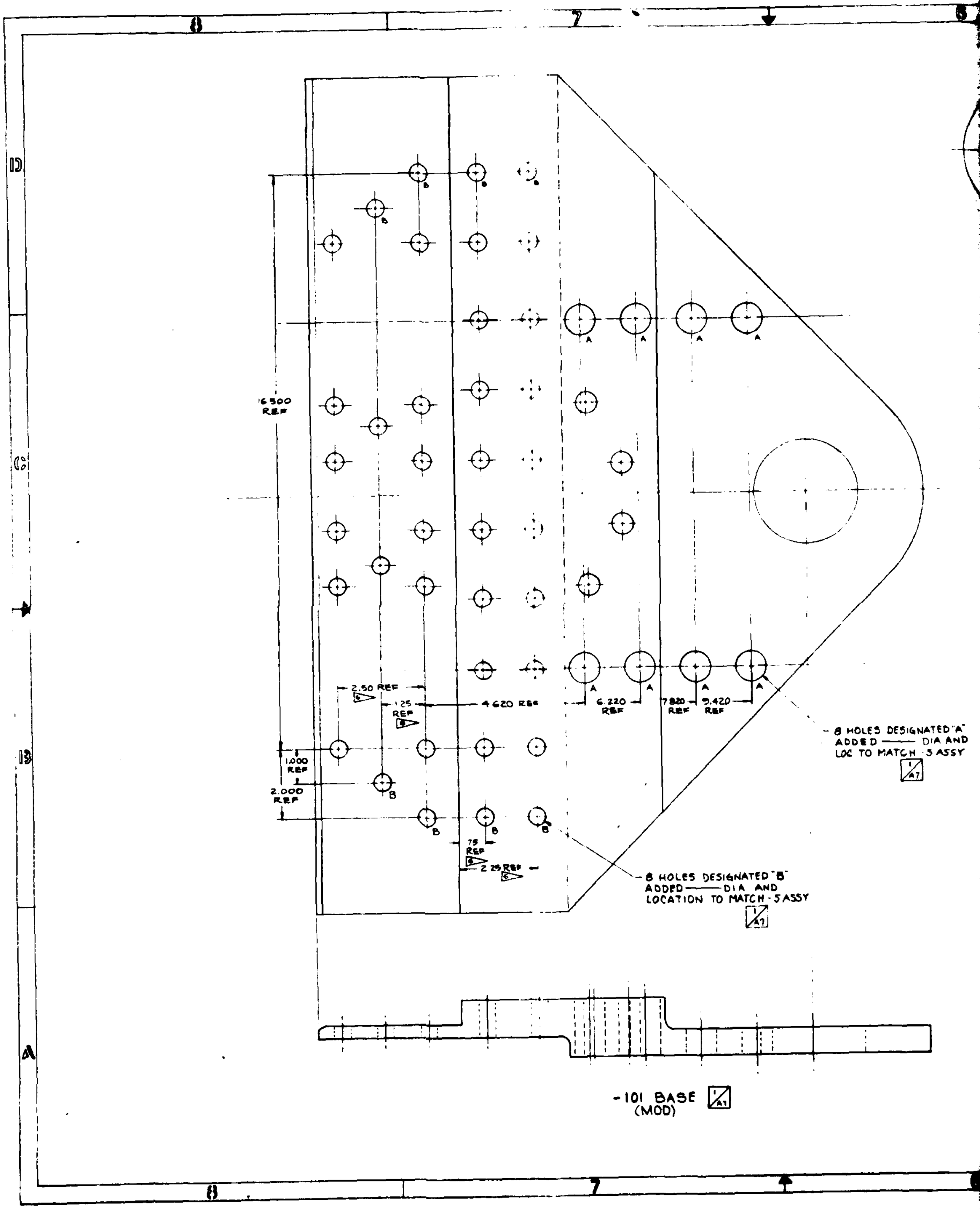
-125		-7	-5	-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
		REF	REF			TT802029-1		DRILL FIXTURE ASSY				
		4	4			NAS1308-40	1 B6	HEX BOLT				
		34	34			NAS1308-23	1 B6	HEX BOLT				
		38	38			AN960-816	1 A6	WASHER				
		38	38			MS51968-15	1 A6	HEX NUT				
		8	8			MS51968-21	1 D6	HEX NUT				
		80	80			AN960-1416	1 D6	WASHER				
		8	8			NAS1314-96	1 D6	HEX BOLT				
		16	16			AN960-1016	1 B6	WASHER				
		10	10			MS51968-21	1 B6	HEX NUT				
		10	10			NAS6210-40	1 B6	HEX BOLT				
		2	2			MS51968-9	1 B6	HEX NUT				
		2	2				1 B6	SOC HD CAP SCR	STEEL-BLK OXIDE FIN	3/8-24UNF2A x 2 1/2	COMMERCIAL	
		1	1				1 A7	PIN, SPRING	STEEL-BLK OXIDE FIN	1/4 DIA x 1.00	COMMERCIAL	
			1			YSK101018-6 ASSY	1 D6	ROD END ASSY	(EXISTING)			
1						YSK101019 ITEM 9	2 B6	PIN	(EXISTING)			
		1	1			YSK101019 ITEM 13	1 A6	RING-ADJ	(EXISTING)			
		1				YSK101018-5 ASSY	1 D6	ROD END ASSY	(EXISTING)			
1						-125	2 B5	LUG	4130 HRS NORMALIZED	.800 x 1.0 x 3.50	MIL-S-18729	
—		1	1			-123	1 A6	PIN ASSY				9
		1	1			-121	1 A6	SHIM-RING	C1010 CRS (.002 LAMINATED)	.062 x 4.00 x 4.00	[illegible]	[illegible]
		4	4			-119	1 A7	SHIM	C1010 CRS (.002 LAMINATED)	.062 x 1.80 x 3.00	[illegible]	[illegible]
		4	4			-117	1 B6	SHIM-CLEVIS	C1010 CRS (.002 LAMINATED)	.020 x 2.00 x 5.20	[illegible]	[illegible]
		4	4			-115	1 B6	BAR-CLEVIS	4130 HRS NORMALIZED	.750 x 2.00 x 13.14	MIL-S-18729	9, 9
		1	1			-113	1 A7	SPACER	4130 HRS NORMALIZED	.125 x 3.00 x 20.00	MIL-S-18729	9
		1	1			-111	1 A6	SPACER	4130 HRS NORMALIZED	.125 x 3.95 x 20.00	MIL-S-18729	9
		1	1			-109	1 C7	PLATE (MOD)	M/F YSK101019 ITEM 8	(EXISTING)		9
		2	2			-107	1 A6	PLATE-CLEVIS CTR	4130 HRS NORMALIZED	1.500 x 3.62 x 6.55	MIL-S-18729	9
		1	1			-106	1 D7	PLATE	4130 HRS NORMALIZED	.180 x 3.30 x 7.12	MIL-S-18729	8, 9
		1	1			-105	1 B7	PLATE	4130 HRS NORMALIZED	.180 x 3.30 x 7.12	MIL-S-18729	8, 9
		1	1			-103	1 B6	PLATE-UPPER	M/F YSK101019 ITEM 6 (EXISTING)			9
		1	1			-101	1 A7	PLATE-BASE	M/F YSK101019 ITEM 4 OR 35 (EXISTING)			9
		—		2		-7	1 A7	ASSY (FATIGUE)				
			—		2	-5	1 A7	ASSY (STATIC)				
				—		-3	1 A4	INSTALLATION (FATIGUE)				
					—	-1	1 A4	INSTALLATION (STATIC)				
QUANTITY REQUIRED												

PARTS LIST

TEST FIXTURE (MOD)
TENSILE, STATIC AND FATIGUE,
STIFFENED PANEL

J | TT802025 | SHEET 1

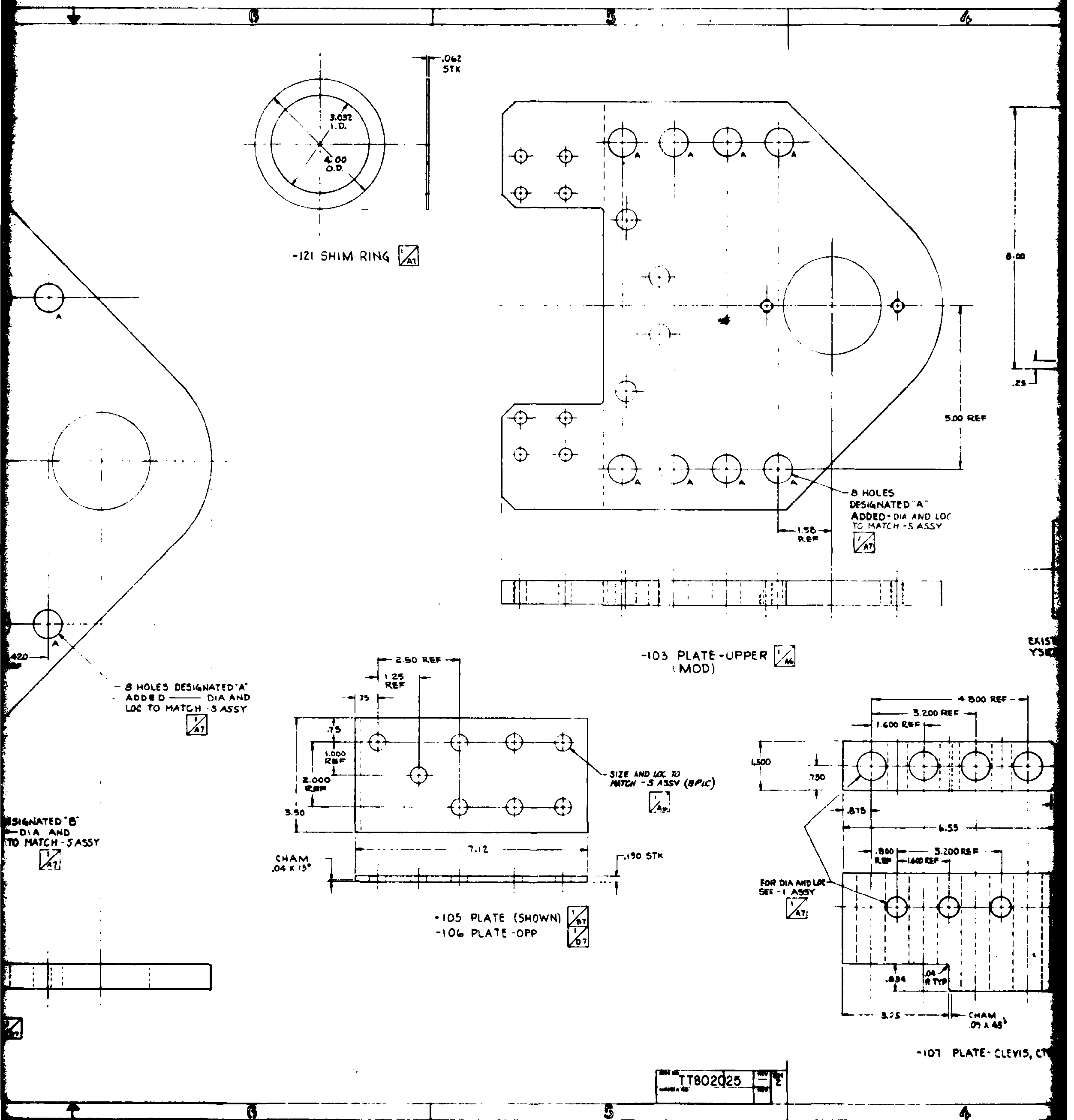
2



16.500 REF
2.50 REF
1.25 REF
4.620 REF
6.220 REF
7.820 REF
9.420 REF
1.000 REF
2.000 REF
.75 REF
2.25 REF
8 HOLES DESIGNATED "A" ADDED ——— DIA AND LOC TO MATCH -5 ASSY
8 HOLES DESIGNATED "B" ADDED ——— DIA AND LOCATION TO MATCH -5 ASSY
A
B

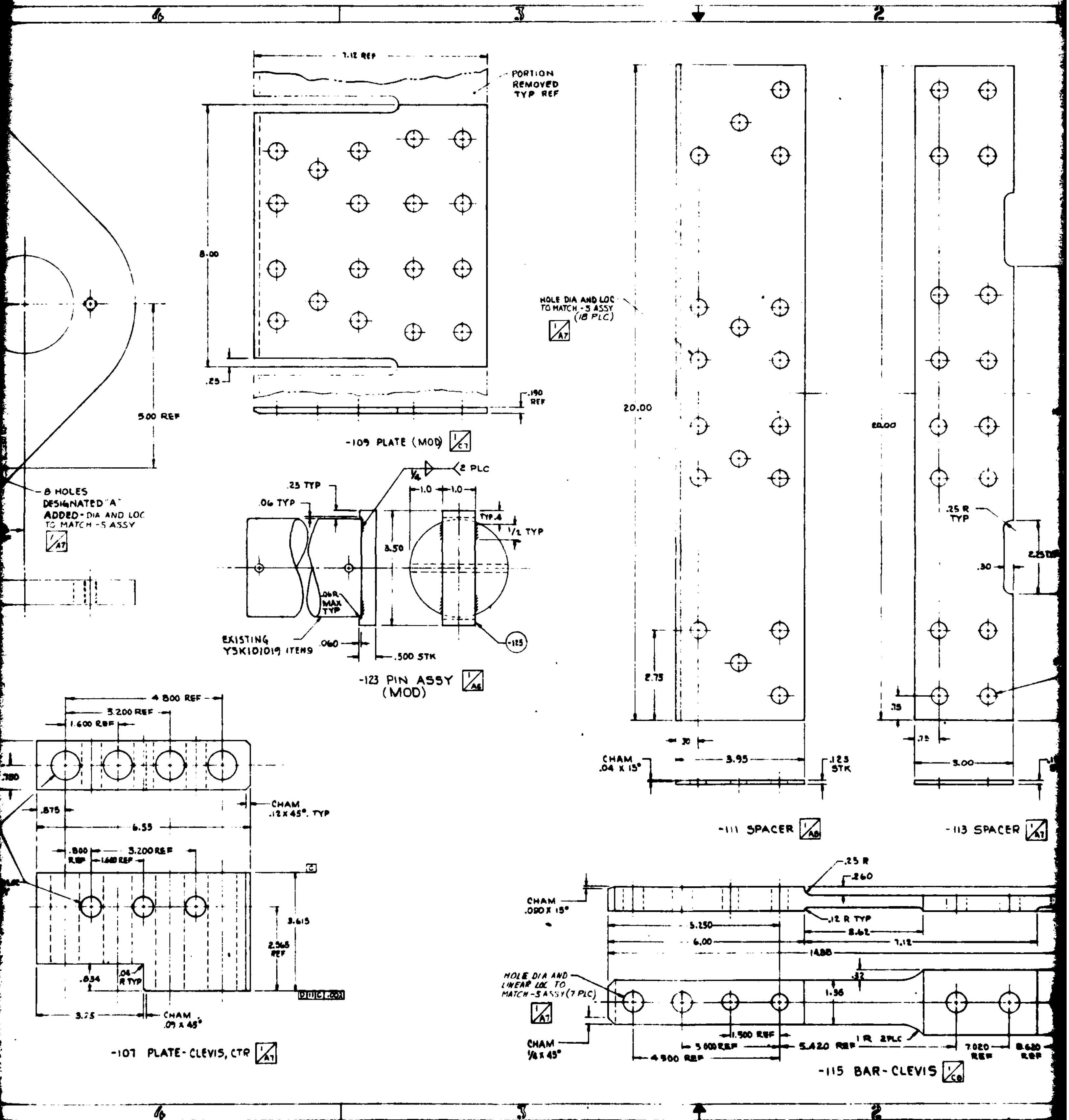
-101 BASE
(MOD)

2 1



.062 STK
3.032 I.D.
4.00 O.D.
-121 SHIM-RING
8.00
.25
5.00 REF
8 HOLES DESIGNATED "A" ADDED - DIA AND LOC TO MATCH -5 ASSY
1.58 REF
-103 PLATE-UPPER (MOD)
.420
8 HOLES DESIGNATED "A" ADDED ——— DIA AND LOC TO MATCH -5 ASSY
DESIGNATED "B" — DIA AND TO MATCH -5 ASSY
2.50 REF
1.25 REF
.75
1.000 REF
2.000 REF
3.50
SIZE AND LOC TO MATCH -5 ASSY (8 PLC)
7.12
CHAM .04 X 15°
.190 STK
-105 PLATE (SHOWN)
-106 PLATE-OPP
4.800 REF
3.200 REF
1.600 REF
1.500
.750
.875
6.55
.800 REF
1.600 REF
FOR DIA AND LOC SEE -1 ASSY
.834
.06 R TYP
3.75
CHAM .09 X 45°
-107 PLATE-CLEVIS, CT
EXIST
TT802025

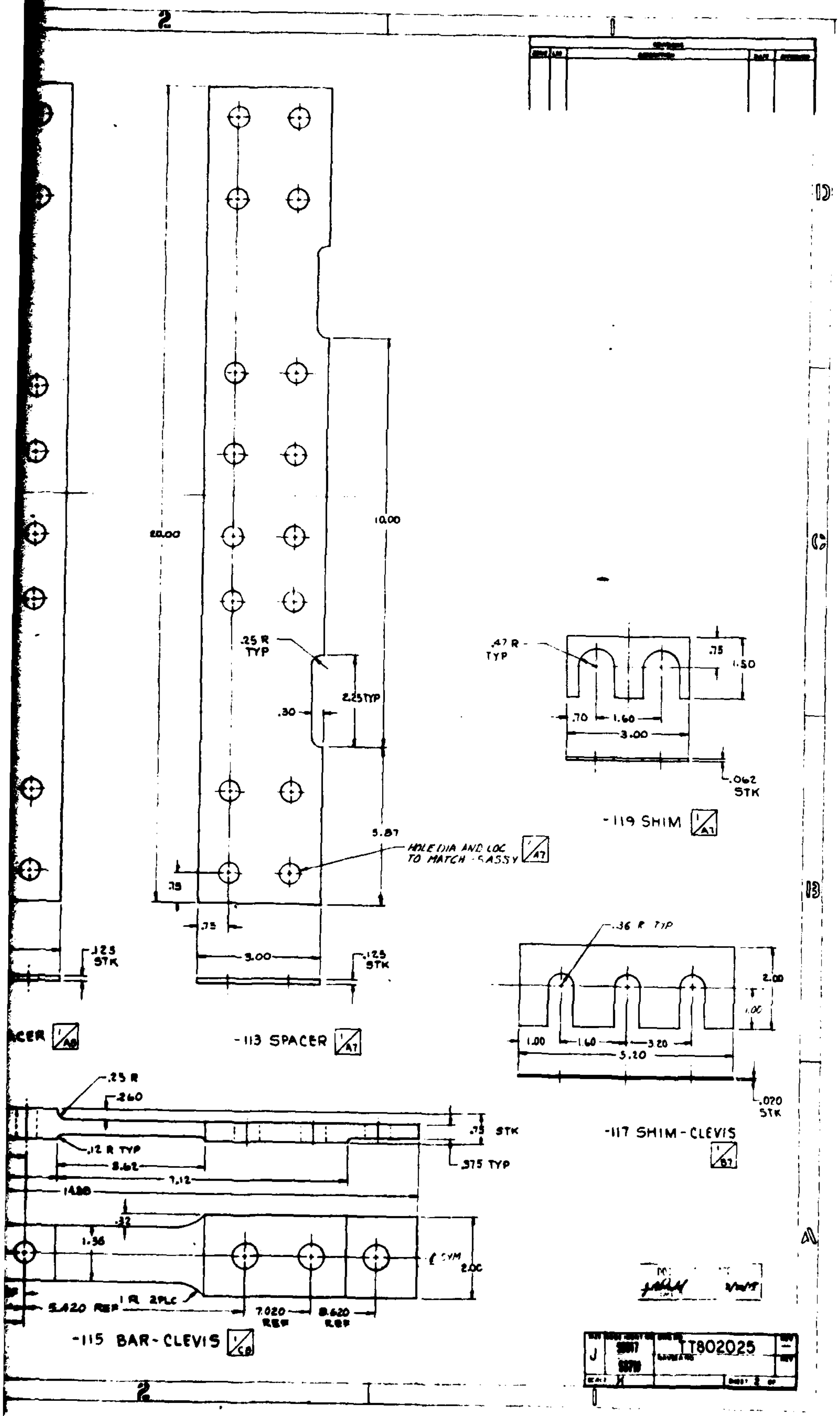
3



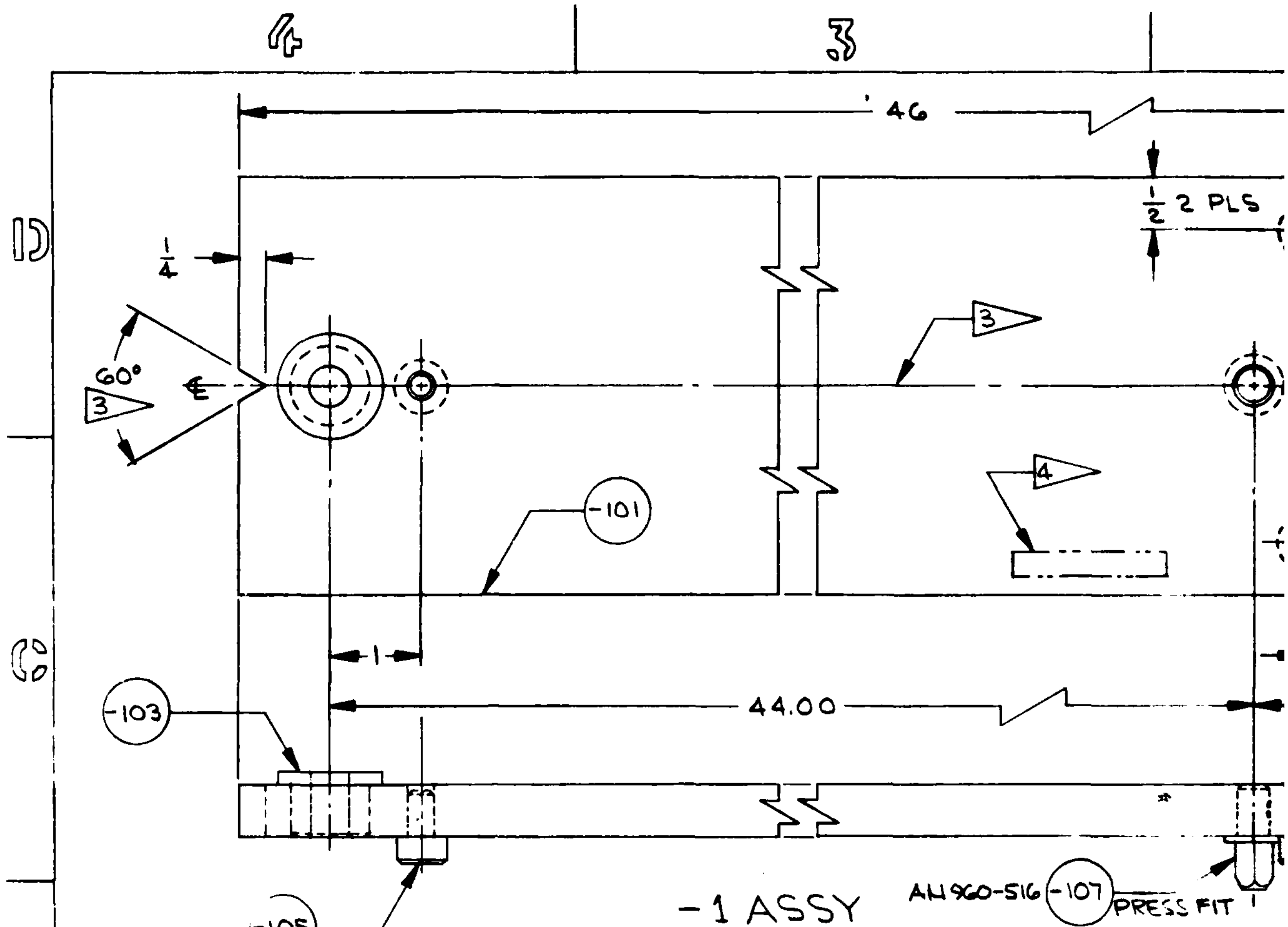
6
3
2
7.12 REF
PORTION REMOVED TYP REF
8.00
.25
5.00 REF
.190 REF
-109 PLATE (MOD)
HOLE DIA AND LOC TO MATCH -5 ASSY (18 PLC)
20.00
20.00
8 HOLES DESIGNATED "A" ADDED - DIA AND LOC TO MATCH -5 ASSY
.25 TYP
.06 TYP
1/4
2 PLC
1.0
1.0
TYP .4
1/2 TYP
3.50
.06R MAX TYP
EXISTING YSK101019 ITEM 9
.060
.500 STK
-125
-123 PIN ASSY (MOD)
2.75
.75
.30
3.95
CHAM .04 X 15°
.125 STK
.25 R TYP
2.25
.30
.75
3.00
-111 SPACER
-113 SPACER
4.800 REF
3.200 REF
1.600 REF
.875
6.55
CHAM .12 X 45°, TYP
.800 REF
1.600 REF
3.200 REF
3.615
2.565 REF
.834
.06 R TYP
3.75
CHAM .09 X 45°
-107 PLATE-CLEVIS, CTR
.25 R
.260
CHAM .090 X 15°
.12 R TYP
5.250
6.00
8.62
7.12
14.88
HOLE DIA AND LINEAR LOC TO MATCH -5 ASSY (7 PLC)
.32
1.36
1.500 REF
1 R 2 PLC
CHAM 1/4 X 45°
3.000 REF
5.420 REF
7.020 REF
8.620 REF
4.500 REF
-115 BAR-CLEVIS
6
3
2

1

4



.25 R TYP
2.25 TYP
.30
10.00
20.00
5.87
.75
3.00
.125 STK
HOLE DIA AND LOC TO MATCH ASSY
-113 SPACER
.47 R TYP
.75
1.50
.70
1.60
3.00
.062 STK
-119 SHIM
.36 R TYP
2.00
1.00
1.60
3.20
5.20
.020 STK
-117 SHIM-CLEVIS
.25 R
.260
.12 R TYP
.75 STK
.375 TYP
7.12
1.36
.32
℄ SYM
2.00
1 R 2PLC
5.420 REF
7.020 REF
8.620 REF
-115 BAR-CLEVIS
J
TT802025



-1 ASSY

				1	AN 960-516	C 3	WASHER
				1	-107	C 3	PIN. DIAMOND
				3	-105	B 4	REST BUTTON
				1	-103	C 4	BUSHING
				1	-101	C 3	PLATE
				–	-1	B 3	DRILL FIXTURE
QUANTITY REQ'D				-1	PART NUMBER	ZONE	DESCRIPTION

PAR

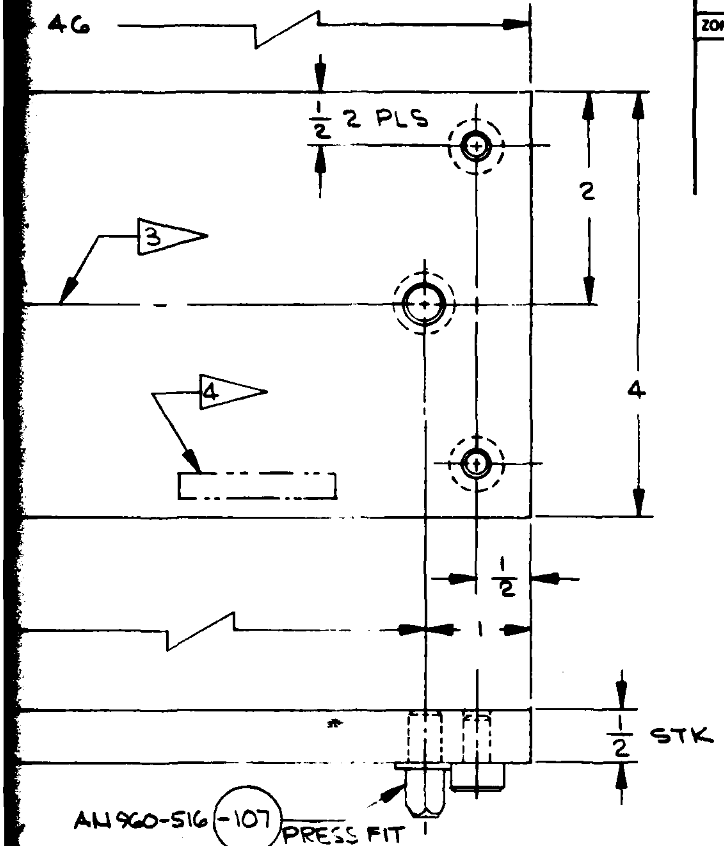
NOTES:
1. BREAK ALL SHARP EDGES .015 R. MAX.
2. ABBREVIATIONS PER MIL-STD-12.
3. PERMANENTLY SCRIBE ℄ MARK ON FACE OF -101. ALIGN "V" NOTCH AND -103 BUSHING WITHIN .010.
4. IDENTIFY IN APPROX AREA INDICATED USING 1/4 IN. MIN CHARACTERS (STEEL STAMP OR VIBRA-ETCH).

ALL MAC
SURFACE
UNLESS
OTHERWI
SPECIFIE

A
4
3

2

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



DOCUMENT RELEASE
J. R. Dodd 8/30/78

ER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
516	C 3	WASHER	STEEL			
107	C 3	PIN. DIAMOND	STEEL- BLK OXIDE	.3743/.3740 OD x 1.0 LG	CL-3-DP-X	CARR LANE MFG. CO. ST LOUIS, MO
105	B 4	REST BUTTON	STEEL- BLK OXIDE	1/2 DIA x 1/4 x 23/32	45704	JERGENS INC CLEVEL. OHIO
103	C 4	BUSHING	STEEL- BLK OXIDE	.3755/.3751 ID .7515/.7518 OD	H-48-8-3/8	CARR LANE MFG. CO. ST. LOUIS, MO
101	C 3	PLATE	STEEL- C1018 CF	1/2 x 4 x 46	QQ-S-634	-
1	B 3	DRILL FIXTURE				

PARTS LIST

-101.
010.
1/4 IN.
CH).

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON:

FRACTIONS	DECIMALS .X	.XX	.XXX	ANGLE
± 1/16	± .1	± .03	± .010	± 2°

ALL MACHINED SURFACES 250 UNLESS OTHERWISE SPECIFIED

CONTRACT NO. N00024-77-C-2032

DRAWN	SAGENDORPH	2-3-78
CHECK	D.A. Bowers	2/8/78
DES SUPV		2/8/78
DES MGR		
GRP MGR		
WEIGHTS	—	
MFG	—	
QA		
SYS ENG		
DRB/CCB		
	CATEGORY	

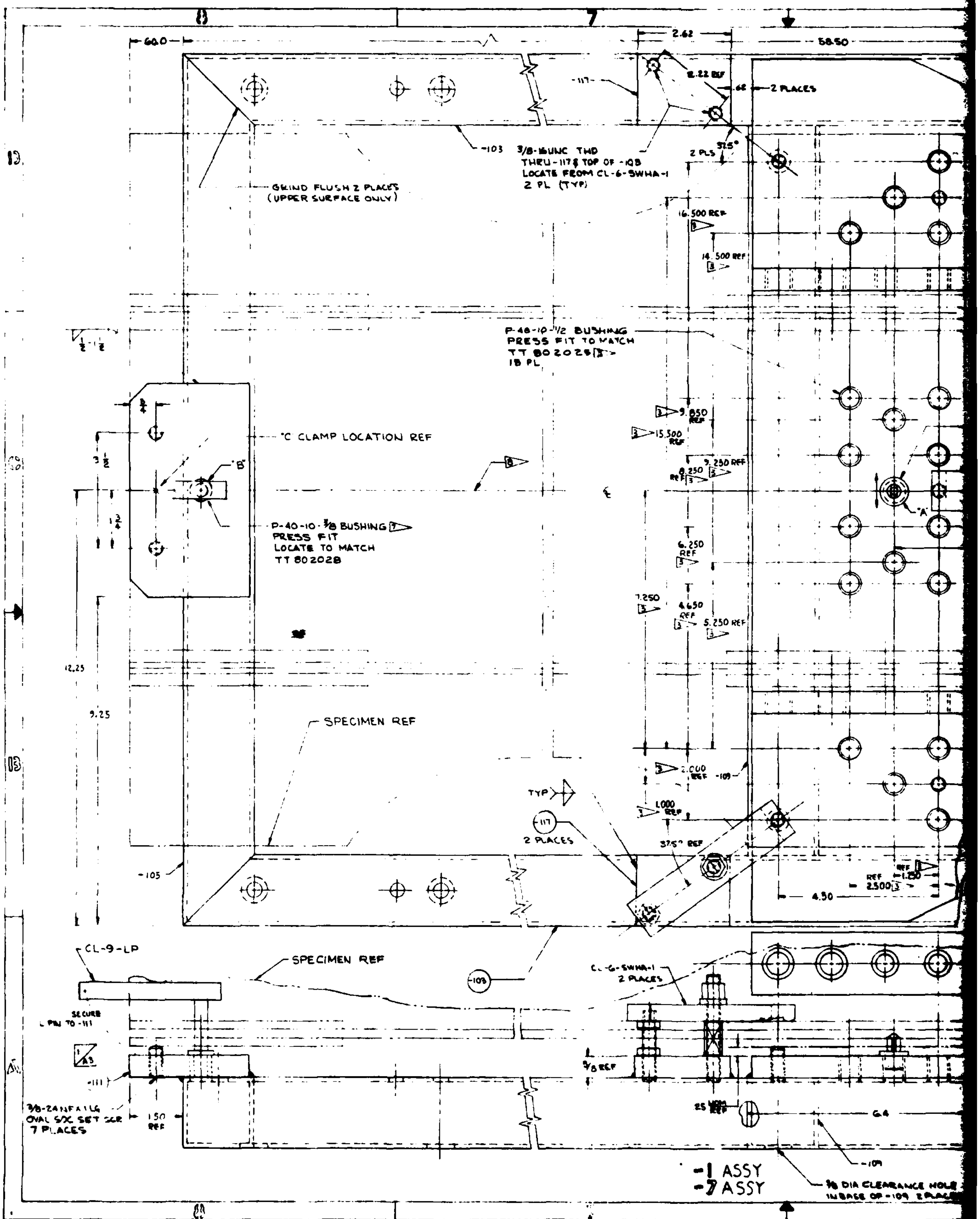
ROHR ROHR MARINE, INC.

3KSES SURFACE EFFECT SHIP

TOOLING HOLES DRILL FIXTURE

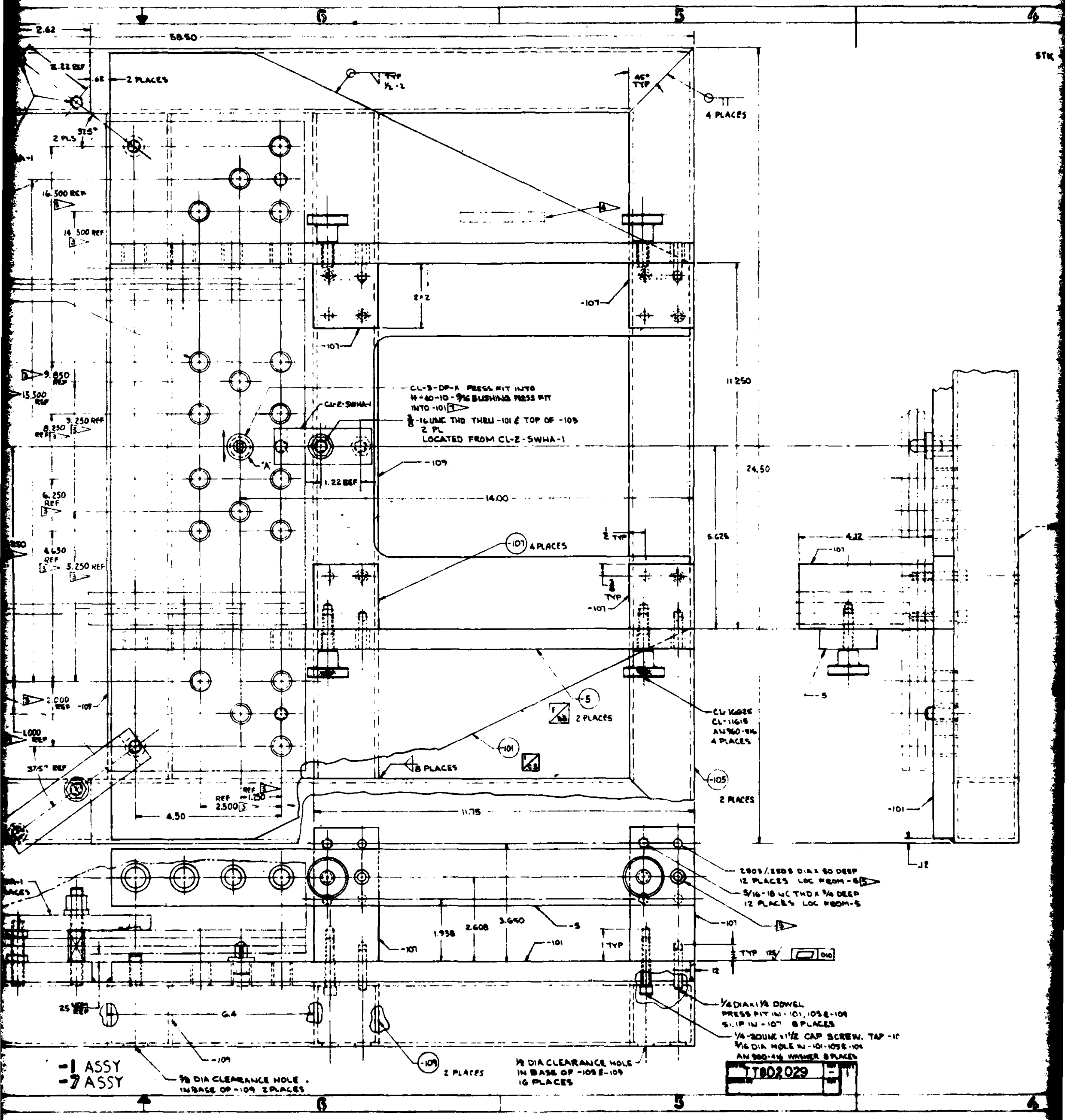
SIZE	CODE IDENT NO	DWG NO	REV
C	55917	TT802028	—
	53711	NAVSEA NO	REV

SCALE FULL SHEET 1 OF 1



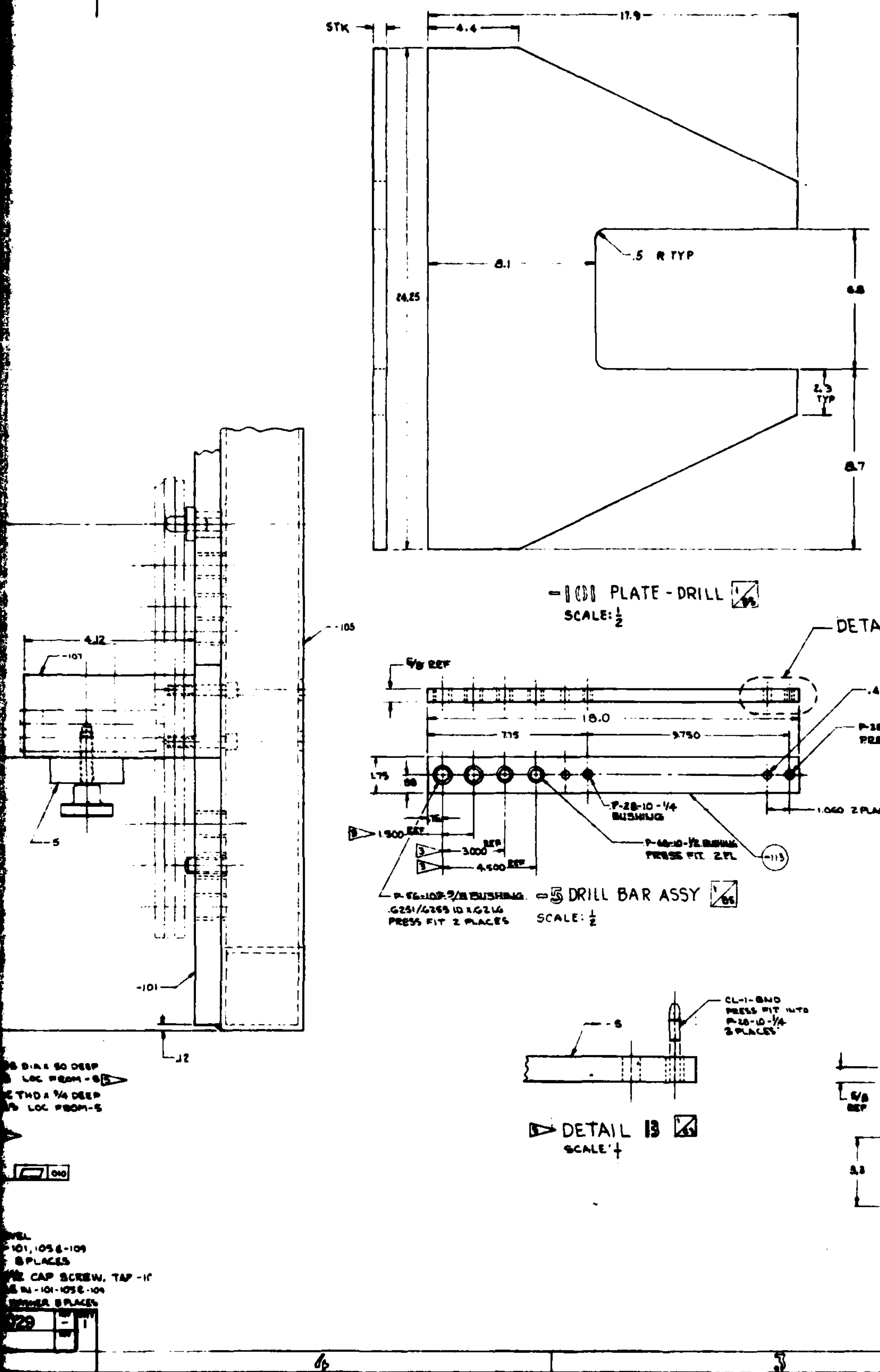
GRIND FLUSH 2 PLACES
(UPPER SURFACE ONLY)
3/8-16UNC THD
THRU-117 & TOP OF -103
LOCATE FROM CL-6-SWHA-1
2 PL (TYP)
2 PLACES
2.62
58.50
16.500 REF
14.500 REF
P-48-10-1/2 BUSHING
PRESS FIT TO MATCH
TT 802025
18 PL
"C CLAMP LOCATION REF
"B"
"A"
P-40-10-3/8 BUSHING
PRESS FIT
LOCATE TO MATCH
TT 802028
9.850 REF
15.500 REF
9.250 REF
6.250 REF
7.250
4.650 REF
5.250 REF
12.25
9.25
SPECIMEN REF
2.000 REF
1.000 REF
TYP
2 PLACES
37.5° REF
4.50
2.500
-103
-105
-109
-111
-117
CL-9-LP
SPECIMEN REF
CL-6-SWHA-1
2 PLACES
SECURE
L PIN TO -111
3/8-24NF A 1 LG
OVAL S/C SET SCR
7 PLACES
1.50 REF
3/8 REF
.25 NOM REF
6.4
3/8 DIA CLEARANCE HOLE
IN BASE OF -109 2 PLACES
-1 ASSY
-2 ASSY

2 1



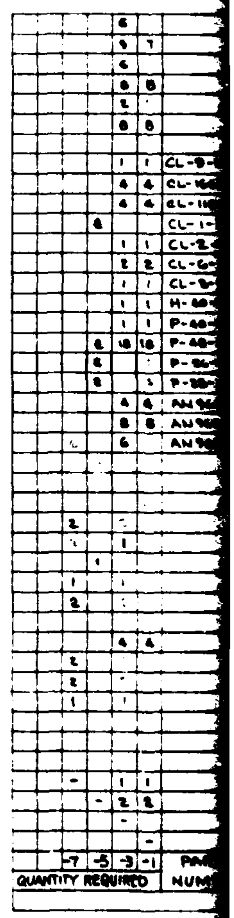
58.50
2 PLACES
4 PLACES
16.500 REF
14.500 REF
9.850 REF
15.500 REF
9.250 REF
8.250 REF
6.250 REF
4.650 REF
5.250 REF
2.000 REF
1.000 REF
37.5° REF
CL-3-DP-A PRESS FIT INTO
H-40-10-9/16 BUSHING PRESS FIT
INTO -101
CL-2-SWHA-1
3/8-16UNC THD THRU -101 & TOP OF -105
2 PL
LOCATED FROM CL-2-SWHA-1
-109
1.22 REF
14.00
-107
4 PLACES
11.250
24.50
5.625
4.12
-105
2 PLACES
8 PLACES
CL-16025
CL-11615
AN960-816
4 PLACES
4.50
2.500
1.250
11.75
-101
.12
.2503/.2505 DIA X .50 DEEP
12 PLACES LOC FROM -5
5/16-18 UC THD X 3/4 DEEP
12 PLACES LOC FROM -5
1.938
2.608
3.650
-5
TYP
1/4 DIA X 1 1/4 DOWEL
PRESS FIT IN -101, -105 & -109
SLIP IN -107 8 PLACES
1/4-20UNC X 1 1/2 CAP SCREW, TAP -10
5/16 DIA HOLE IN -101, -105 & -109
AN960-416 WASHER 8 PLACES
6.4
-1 ASSY
-7 ASSY
3/8 DIA CLEARANCE HOLE
IN BASE OF -109 2 PLACES
1/2 DIA CLEARANCE HOLE
IN BASE OF -105 & -109
16 PLACES
TT802029
6
5
4
STK

3



NOTES.

1. ABBREVIATIONS PER MIL-STD-12
2. BREAK SHARP EDGES .015 R MAX
3. DESIGNATED HOLES MUST COORD WITH MATCHING HOLES IN T ASSY'S & MUST ASSURE THAT TEST SPECIMENS DRILLED USI TT802029 FIXTURE WILL MATE INTERCHANGEABLY WITH TT802025-5 ASSYS.
4. STEEL STAMP OR VIBRO-ETCH IDENTITY (TT802029) IN AREA INDICATED USING 1/4IN MIN HIGH CHARACT
5. AFTER LOCATING .260 DIA HOLE 12 PLACES PRESS FIT CL-1-BND (BULLET NOSE DOWEL) INTO (-5ASSY) P-28-10-1/4 BUSHING. SEE DETAIL "B", ZONE A3, SH 1
6. MAT'L & COMPONENT SUBSTITUTIONS ARE PERMISSIBLE WITH SPECIFIC ENGINEERING APPROVAL
7. a. LOCATE "A" .3751/.3755 DIA HOLE
   b. USING TT802028 DRILL FIXTURE LOCATE "B" .3751/.3755 DIA HOLE IN -111 ENLARGE HOLE AND PRESS FIT P-40-10 BUSHING
   c. ENLARGE "A" DIA HOLE AND PRESS FIT H-40-10 BUSHING & CL-3-DP-X PIN
8. PERMANENTLY SCRIBE ℄ MARK ON FACE OF -1 & -3 ASSY



4

VIATIONS PER MIL-STD-12.

SHARP EDGES .015 R MAX

NATED HOLES MUST COORD WITH MATCHING HOLES IN TT802025-5 YS & MUST ASSURE THAT TEST SPECIMENS DRILLED USING THE 802029 FIXTURE WILL MATE INTERCHANGEABLY WITH BOTH 802025-5 ASSYS.

L STAMP OR VIBRO-ETCH IDENTITY (TT802029) IN APPROX A INDICATED USING 1/4IN MIN HIGH CHARACTERS.

TER LOCATING .250 DIA HOLE 12 PLACES
SS FIT CL-1-BND (BULLET NOSE DOWEL)
O (-5 ASSY) P-28-10-1/4 BUSHING. SEE DETAIL "B",
NE A3, SH 1

TL & COMPONENT SUBSTITUTIONS ARE PERMISSIBLE
H SPECIFIC ENGINEERING APPROVAL

LOCATE "A" .3751/.3755 DIA HOLE

USING TT802028 DRILL FIXTURE LOCATE "B" .3751/.3755 DIA HOLE IN -111 ENLARGE HOLE AND PRESS FIT P-40-10 BUSHING

ENLARGE "A" DIA HOLE AND PRESS FIT H-40-10 BUSHING & CL-3-DP-X PIN

PERMANENTLY SCRIBE ℄ MARK ON FACE OF -1 & -3 ASSY

-7	-5	-3	-1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
		6			2/B3	HEX NUT	STEEL	3/8-16UNC		
		9	7		1/A2	OVAL SOC. SET SCREW	STEEL (NYL SELF LOCKING)	3/8-24UNF x 1 LG		
		6			2/B3	SOC. HD CAP SCREW	STEEL	3/8-16UNC x 1 1/2 LG		
		8	8		1/A5	SOC. HD. CAP SCREW	STEEL	1/4-20UNC x 1 1/4 LG		
		2	·		2/B3	DOWEL	STEEL	3/8 DIA x 3/4 LG		
		8	8		1/A5	DOWEL	STEEL	1/4 DIA x 1 1/4 LG		
		1	1	CL-9-LP	1/A6	"L" PIN	STEEL		CARR LANE MFG CO L.A., CA	
		4	4	CL-16625	1/B6	KNURLED KNOB	STAINLESS STEEL			
		4	4	CL-11615	1/B5	STUD	STAINLESS STEEL			
	8			CL-1-BND	1/A3	BULLET NOSE DOWEL	STEEL			
		1	1	CL-2-SWHA-1	1/C6	SWIVEL HL. CLAMP ASSY	STEEL	3" STUD		
		2	2	CL-6-SWHA-1	1/A7	SWIVEL HL. CLAMP ASSY	STEEL	3" STUD		
		1	1	CL-3-DP-X	1/C6	DIAMOND LOC. PIN	STEEL			
		1	1	H-40-10-5/8	1/C6	BUSHING	STEEL			
		1	1	P-40-10-5/8	1/C8	BUSHING	STEEL			
	8	16	16	P-48-10-1/2	1/C7	BUSHING	STEEL			
	8		:	P-56-10-5/8	1/B6	BUSHING	STEEL			
	8		1	P-28-10-1/4	1/B3	BUSHING	STEEL		CARR LANE MFG CO L.A., CA	
		4	4	AN960-516	1/B6	WASHER				
		8	8	AN960-416	1/A5	WASHER				
6		6		AN960-616	2/A3	WASHER				
2		-		-117	1/B7	BLOCK	6061-T651 AL ALY TOOLING PLATE	5/8 x 2.0 x 2.62	QQ-A-250/11	
1		1		-116	2/A6	PLATE	6061-T651 AL ALY TOOLING PLATE	1/2 x 22.00 x 24.50	QQ-A-250/11	
	1			-113	1/B3	BAR	6061-T651 AL ALY TOOLING PLATE	5/8 x 1.75 x 18.00	QQ-A-250/11	
1		1		-111	1/A8	PLATE	6061-T651 AL ALY TOOLING PLATE	5/8 x 3.9 x 6.0	QQ-A-250/11	
2		:		-109	1/A6	RAIL-INNER	6063-T52 AL ALY SQ EXTR TUBE SC	2.0 x 2.0 x .125 x 20.5	QQ-A-200/9	
				-						
		4	4	-107	1/C8	PILLAR	1018 CF STL SQ BAR	2.00 x 2.00 x 4.12	QQ-S-634	
2				-105	1/B6	RAIL-END	6063-T52 AL ALY SQ EXTR TUBE SC	2.0 x 2.0 x .125 x 24.5	QQ-A-200/9	
2		·		-103	1/A7	RAIL-SIDE	6063-T52 AL ALY SQ EXTR TUBE SC	2.0 x 2.0 x .125 x 58.5	QQ-A-200/9	
1		1		-101	1/B3	PLATE-DRILL	6061-T651 AL ALY TOOLING PLATE	3/8 x 17.9 x 24.25	QQ-A-250/11	
-		1	1	-7	1/A7	FRAME WELDMENT				
	-	2	2	-5	1/B3	DRILL BAR ASSY				
		-		-3	2/A5	FIXTURE ASSY-LONG				
			-	-1	1/B7	FIXTURE ASSY				

QUANTITY REQUIRED

PARTS LIST

.9 x 45° CHAMFER 2 PLACES

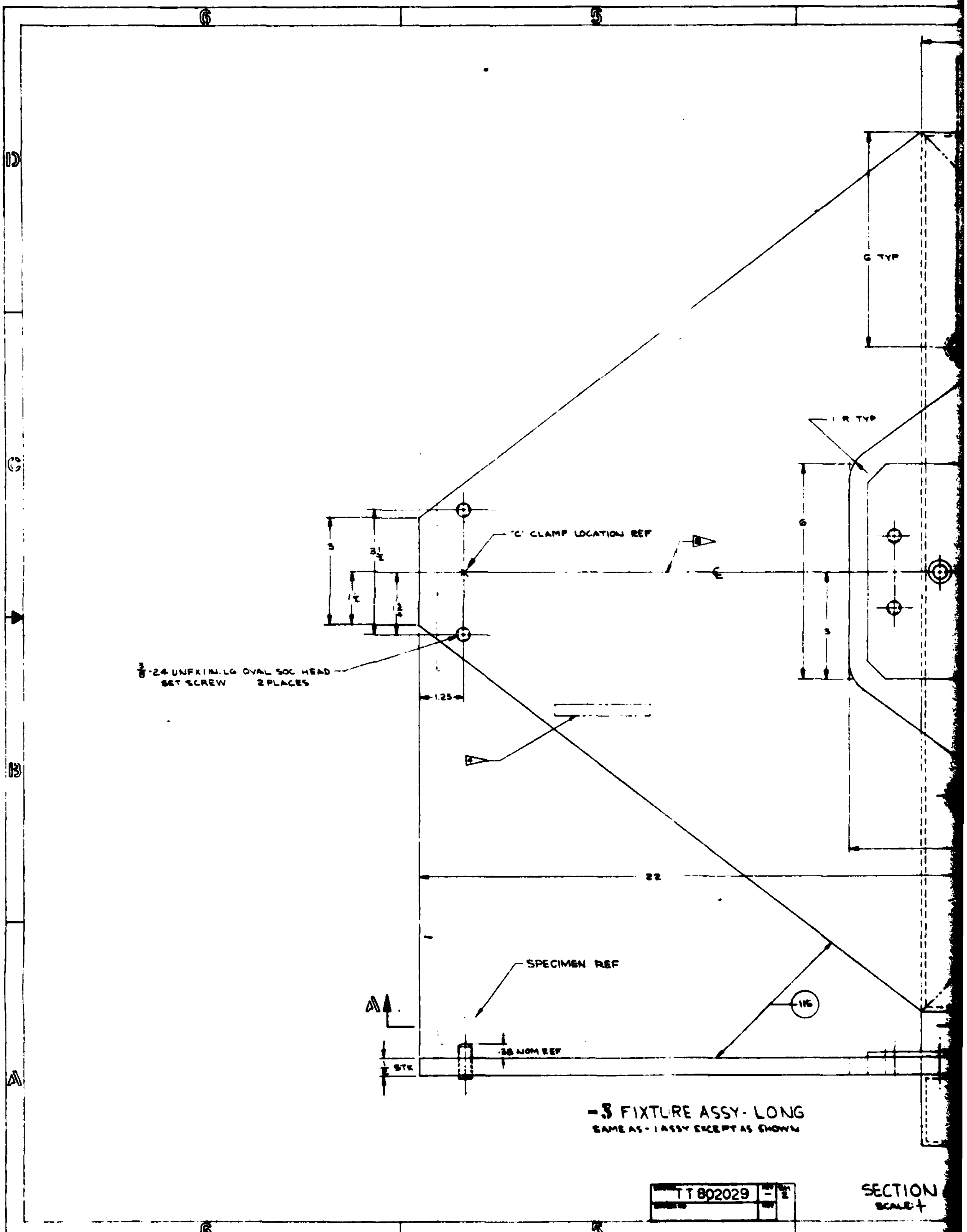
PLATE

DOCUMENT RELEASE

ALL MACHINED SURFACES 250/ UNLESS OTHERWISE SPECIFIED

SPECIMEN DRILL FIXTURE

J TT802029



-3 FIXTURE ASSY - LONG

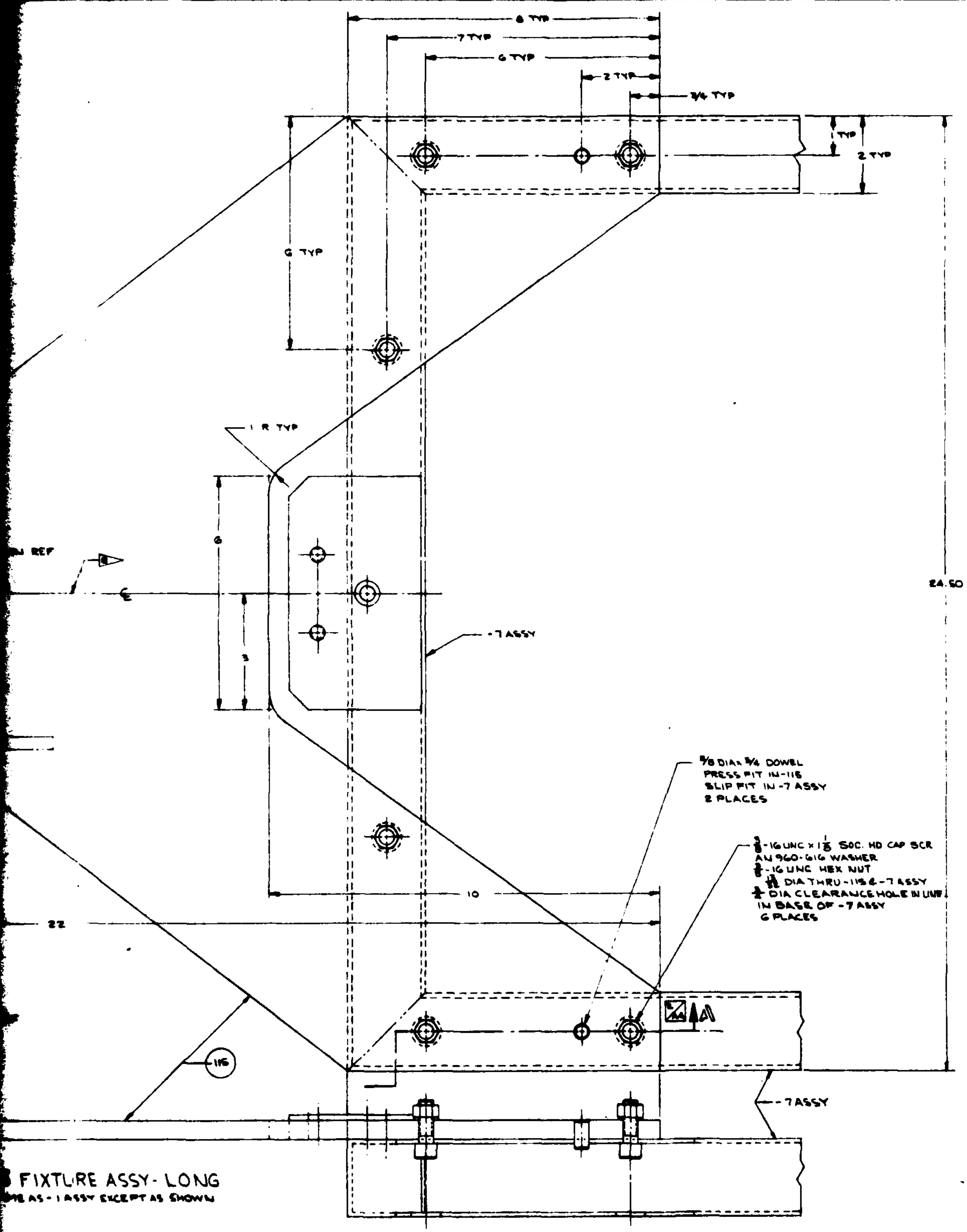
SAME AS -1 ASSY EXCEPT AS SHOWN

TT 802029	-	2

SECTION

SCALE $\frac{1}{4}$

2'


8 TYP
7 TYP
6 TYP
2 TYP
3/4 TYP
TYP
2 TYP
6 TYP
1 R TYP
REF
6
3
24.50
-7 ASSY
5/8 DIA x 3/4 DOWEL
PRESS FIT IN -115
SLIP FIT IN -7 ASSY
2 PLACES
3/8-16 UNC x 1 1/8 SOC. HD CAP SCR
AN 960-616 WASHER
3/8-16 UNC HEX NUT
DIA THRU -115 & -7 ASSY
DIA CLEARANCE HOLE IN LINE
IN BASE OF -7 ASSY
6 PLACES
10
22
A
115
-7 ASSY
FIXTURE ASSY - LONG
AS -1 ASSY EXCEPT AS SHOWN
SECTION A-A
SCALE

TT 802029 | - | 2

3

1

2

D

64.50

C

B

A

DOCUMENT RELEASE

J

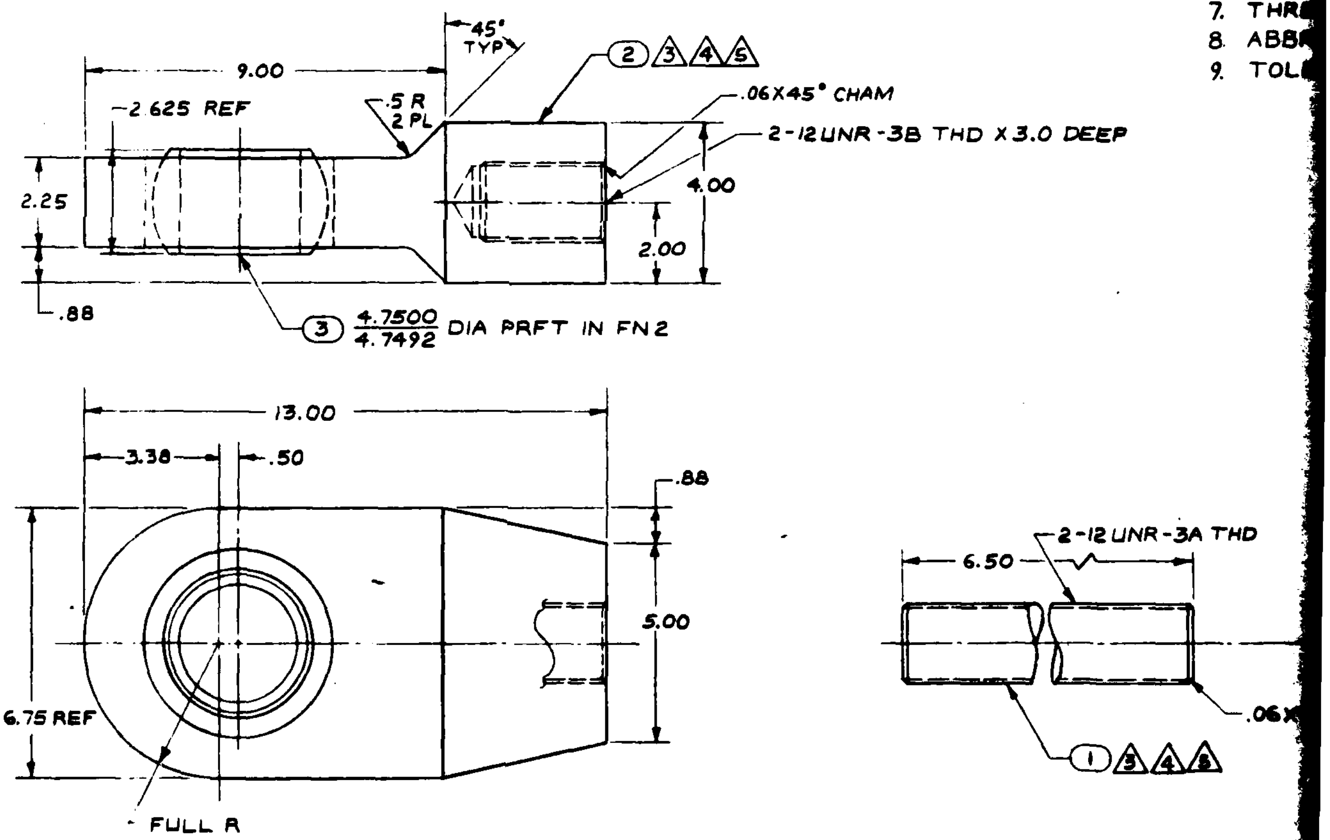
TT802029

2

D-447

PARTS LIST										
FIND NO	QTY REQD	ZONE	WEIGHT-LBS		PART NO	CODE IDENT	DESCRIPTION	MATERIAL	SPEC	REMARKS
			UNIT	TOTAL						
1	1		N/A	N/A	TT802042-1		STUD - 2" O.D. X 7.50"	D6AC HF	AMS 6431	
2	1				-2		ROD EYE - 4" PL X 6.75" X 13.00"	D6AC HF	AMS 6431	
3	1				-3		BALL JOINT - 3" DIA			TORRINGTON NO. 30SF48 OR EQUIV

GENER
1. MACH
2. BREA
3 FINIS
4 NORM
MACH
BALL
5 HEAT
200 K
QUEN
DOUBL
6. TEST
STUD
YSK
TT
FAT
7. THR
8. ABB
9. TOL



2

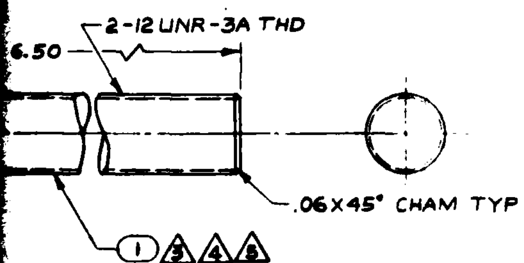
REMARKS
TORRINGTON NO. 30SF48 OR EQUIV

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

GENERAL NOTES (UNLESS OTHERWISE SPECIFIED)

1. MACHINED SURFACES TO BE 63√ MAX.
2. BREAK ALL SHARP EDGES.
3. FINISH: BLACK OXIDE PER MIL-C-13924A (CLASS 1).
4. NORMALIZE AND TEMPER BEFORE ROUGH MACHINING TO BRINELL 285 MAX (STD 10 MM BALL).
5. HEAT TREAT BEFORE FINAL MACHINING TO 200 KSI MIN, 220 KSI MAX TENSILE STRENGTH. QUENCH IN 325°-400°F SALT. SNAP TEMPER IN SALT. DOUBLE TEMPER AT 1090°F, 6 HOURS EACH CYCLE.
6. TEST FIXTURE END USE: THE ROD EYE AND STUD PER THIS DRAWING REPLACE THE YSK101019-6 ASSY USED WITH THE TT802025-3 INSTL FOR STIFFENED PANEL FATIGUE TESTING.
7. THREADS ARE FROM ANSI B1.1.
8. ABBREVIATIONS PER MIL-STD-12C.
9. TOLERANCES: .X = ± .1
   .XX = ± .03
   .XXX = ± .010
   ANGLES = ± 2°

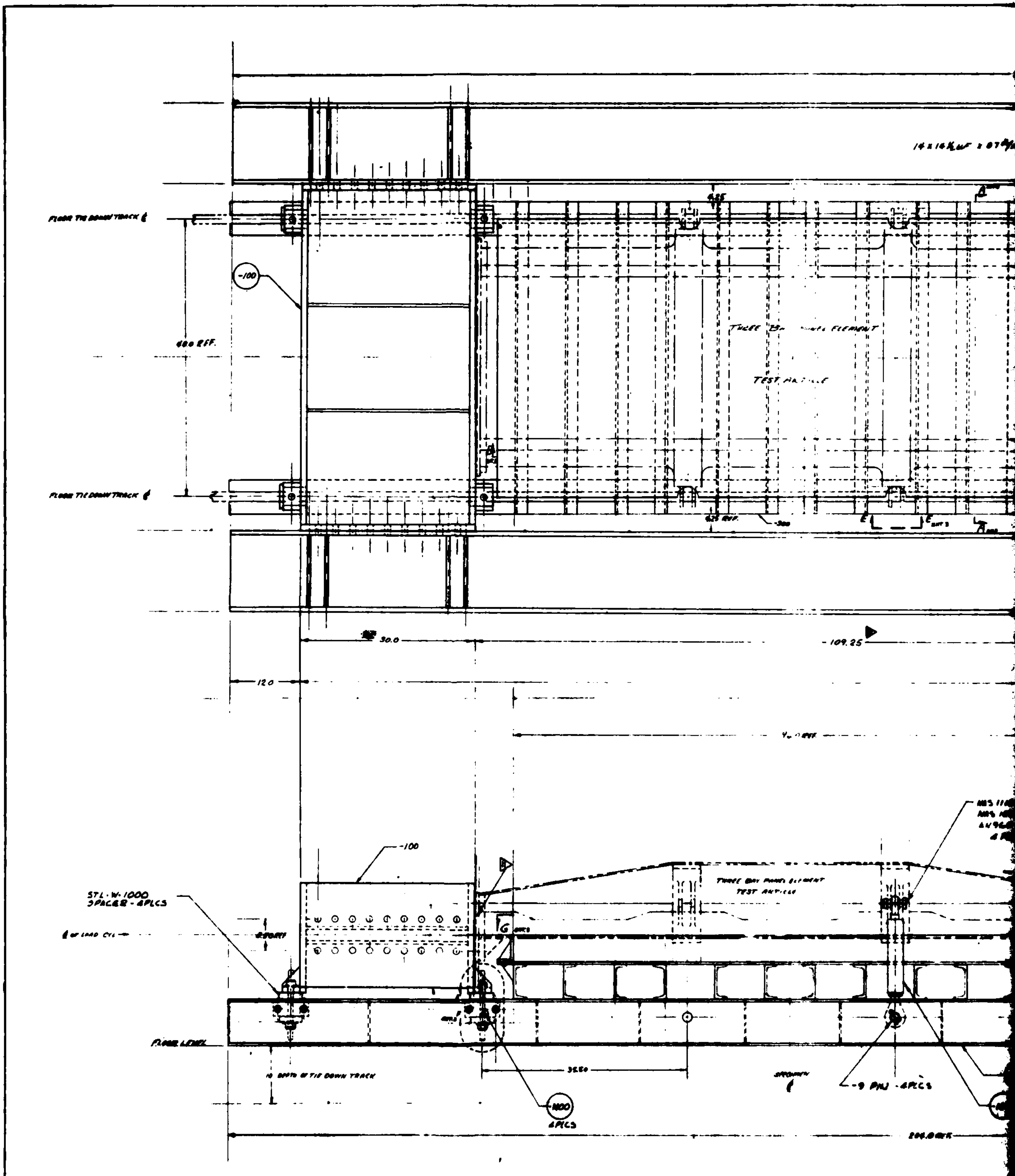
D X 3.0 DEEP



DOCUMENT RELEASE

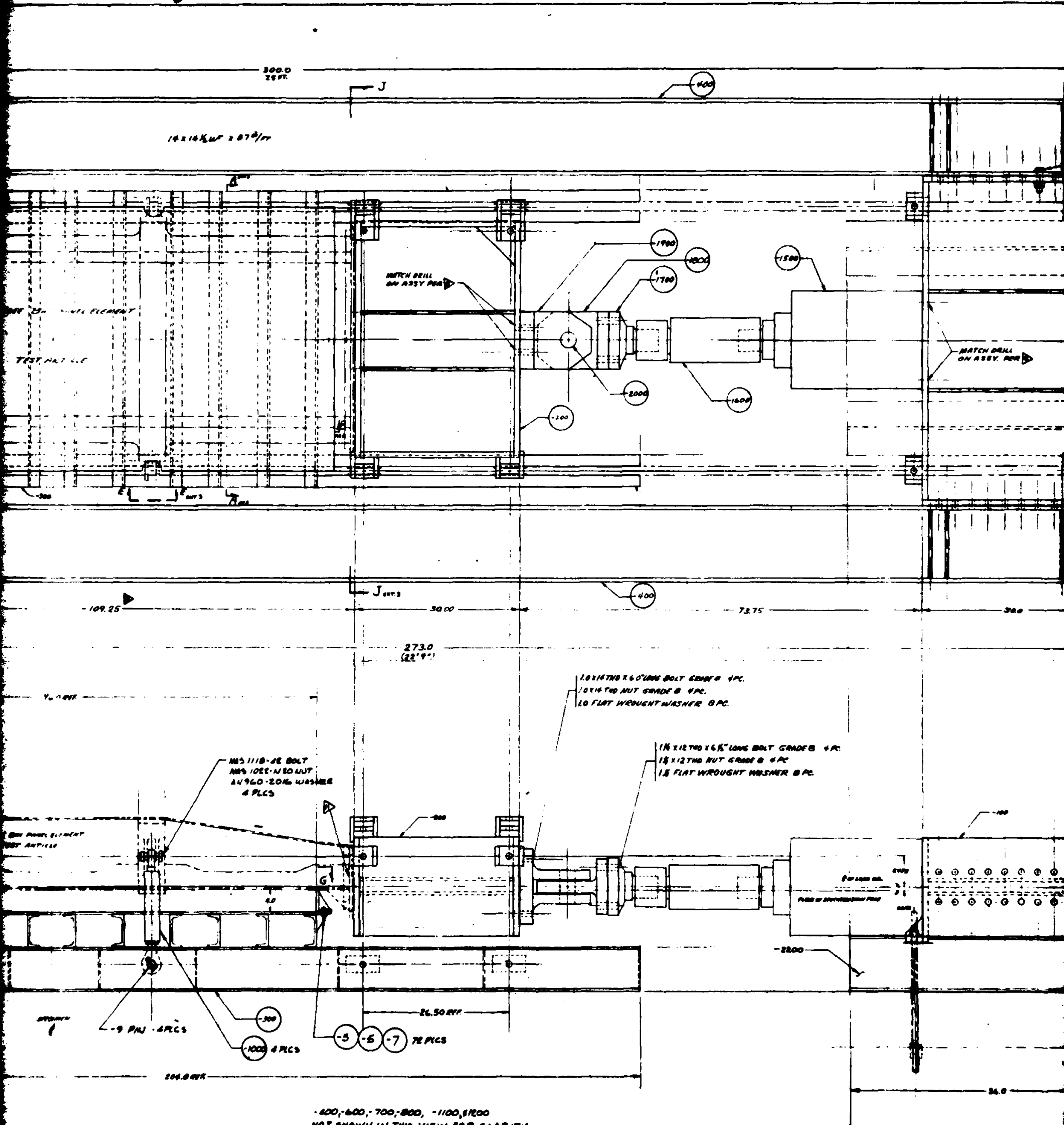
CONFIG MGT DATE 2/2/79

CONTRACT NO. N00024-77-C-2032			ROHR MARINE, INC.	3KSES SURFACE EFFECT SHIP
DRAWN	AL WEISS	2-9-79	ROD EYE & STUD STRUCTURAL TEST - 3KSES	
CHECK	D.A. Bowers	2-9-79		
DES SUP	[illegible]	2-9-79		
DES MGR	R. Anderson	2/12/79		
GRP MGR	—			
WEIGHTS	—			
MFG	—			
QA	[illegible]	2/12/79		
SYS ASSU	N.A.	2/12/79	SIZE D, CODE IDENT NO 55017 / 53711	DWG NO TT802042, REV —
DIR ENG	[illegible]	2/12/79		NAVSEA NO
SYS ENG	[illegible]	2/12/79		
DRB/CCB	[illegible]	2/21/79		
MATL/PROC	[illegible]	2/1/79	SCALE HALF	SHEET 1 OF 1



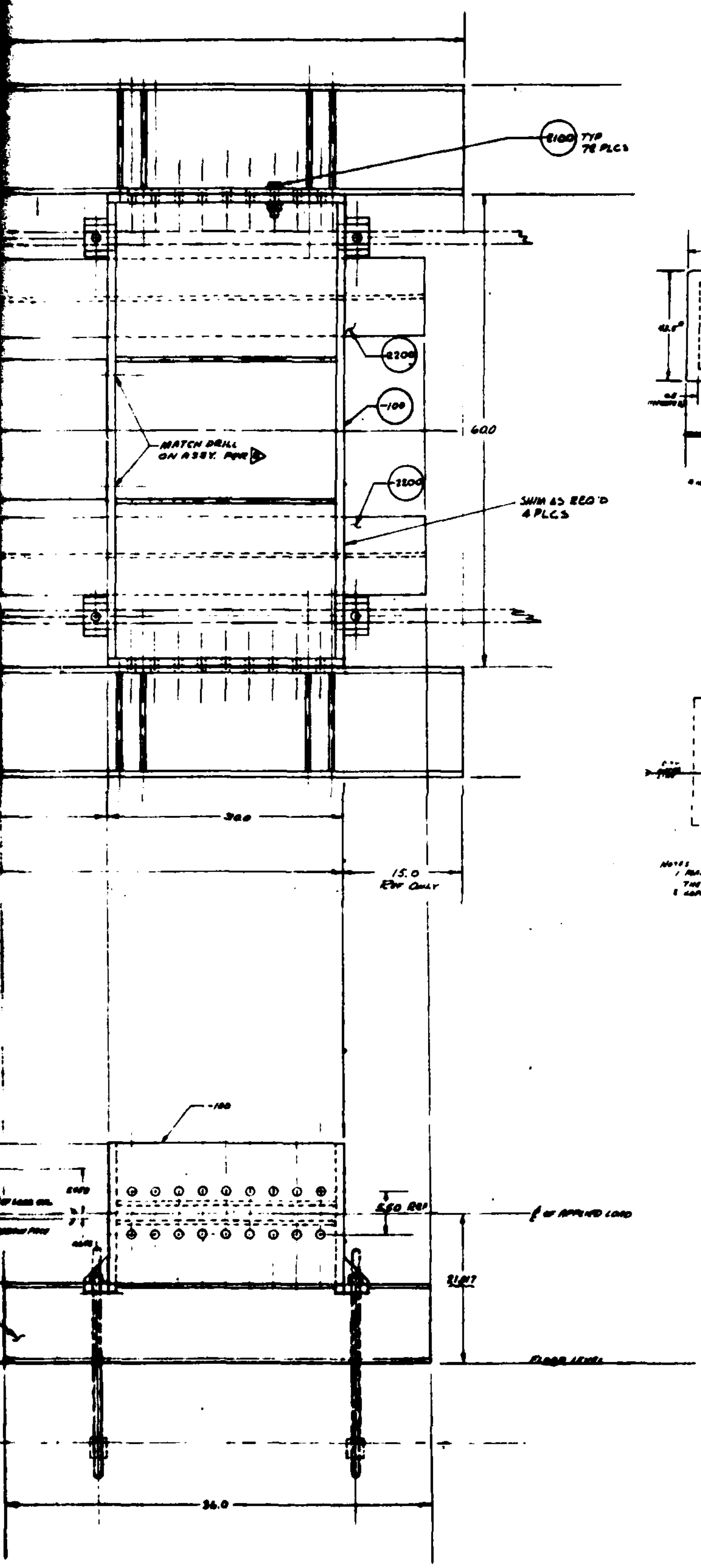
-1 BASIC TEST FIXTURE ASSY.

2 1

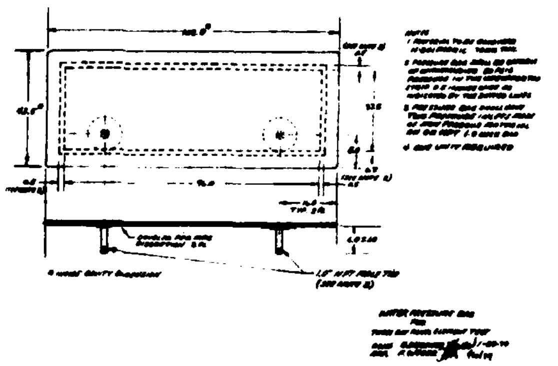


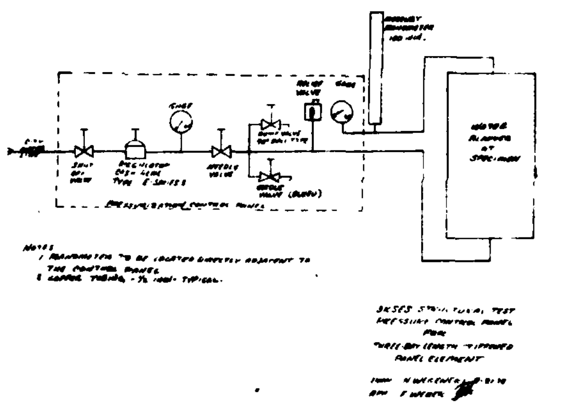
C TEST FIXTURE ASSY.

3 1



L/M CONTINUED ON SHEET 8





13. ENDS OF SPECIMEN TO BE "POTTED" WITH DEVCON "PLASTIC STEEL." APPROX. 0.75" THK EACH END TO ALLOW FOR FIT-UP TOLERANCES.

▷ 100 IS DIMENSION AT A NOMINAL AXIAL STRESS OF 25 KSI. ACTUAL TEST SET-UP DIMENSION TO BE 100.50 TO ACCOUNT FOR SPECIMEN SHORTENING UNDER COMPRESSION LOAD.

▷ THE SPECIMEN ATTACH HOLE PATTERN (OF [illegible] HOLES) TO BE LOCATED ON -300 AND -100 USING EXISTING SPECIMEN HOLE TEMPLATE ALIGNED WITHIN 0.050 ON SCRIBED CENTERLINES.

10. -300 ASSY'S TO BE BOLTED TO LAB. FLOOR RAILS AT 16 LOCATIONS EACH SIDE WITH [illegible], TU, W, & N'S FROM STOCK.

9. -400 BEAMS TO BE SUPPORTED FROM LABORATORY FLOOR ON INSTALLATION AS REQ'D.

▷ INSTALLATION OF [illegible] CLEVIS AND HYDRAULIC LOAD CYLINDER SHALL BE ON ℄ OF TEST SPECIMEN AND LOAD [illegible]

▷ BACK SPOTFACE 1.13 DIA UNDER -308 CHANNELS.

▷ HOLE PATTERN ℄ TO BE 20.[illegible] FROM ℄ OF -301 PLATE - HOLE PATTERN SPACING TO BE MATCH-DRILLED TO -800 PRESSURE FRAME

▷ HOLE PATTERN ℄ TO BE 20.0 FROM ℄ OF -301 PLATE - HOLE PATTERN SPACING TO BE MATCH-DRILLED TO -700 PRESSURE FRAME ASSY

▷ HOLE PATTERN ℄ TO BE 20.00" FROM ℄ OF -301 PLATE - HOLE PATTERN SPACING TO BE MATCH-DRILLED TO -600 PRESSURE FRAME ASSY

▷ HOLE PATTERN ℄ TO BE 49.10" FROM ℄ OF -301 PLATE - HOLE PATTERN SPACING TO BE MATCH-DRILLED TO -500 PRESSURE FRAME ASSY.

▷ DRILL HOLE PATTERN IN -400 [illegible] USING TEMPLATE PER NOTE 1

▷ DRILL HOLE PATTERN IN TWO -103 SIDE PLATES PER TEMPLATE [illegible]; HOLES TO BE IN LINE WITHIN 0.030 ACROSS -103 SIDE PLATES

NOTES:

QUANTITY

4

N SHEET 2

-1400	-1300	-1200	-1100	-1000	-900	-800	-700	-600	-500	-400	-300	-200	-100	1	PART NUMBER	ZONE	DESCRIPTION	MATERIAL	MATERIAL SIZE	MATERIAL SPEC	PROCESS
														2	-2200		BEAM	STRUCTURAL STEEL	[illegible] X 36	[illegible] A36	[illegible]
														1	-2000		PIN		501-200-3		
														1	-1900		CLEVIS		501-206		
														1	-1800		LUG		501-201		
														1	-1700		ADAPTER		501-206		
														1	-1600		LOAD CELL	TRANSDUCERS INC	[illegible]	SN 19926	EXISTING @ETL
														1	-1500		LOAD CYLINDER	MILLER MODEL H648	10 INCH BORE	[illegible] INCH STROKE	EXISTING
2															-1413		NUT	GRADE 8	3/4" X 16THD		
4															-1411		WASHER	COMM. - HARDENED	3/4" ID		
2															-1409		BOLT	GRADE 8	3/4" DIA X 16THD X 4.0" LONG		
1															-1407		WASHER	COMM. - HARDENED	3/8" ID		
1															-1405		PLATE	HOT ROLL STEEL PLATE	1.0 THK X 1.75 X 4.0		
1															-1403		NUT	GRADE 8 NUT	3/8" X 16THD		
1															-1401		BOLT	GRADE 8	3/8 DIA X 16THD X [illegible]" LONG		
	2														-1303		PLATE, CLEVIS SIDE	HOT ROLL STEEL PLATE	3/4 THK X 8.6 X 3.25		
	1														-1301		PLATE, CLEVIS BASE	HOT ROLL STEEL PLATE	1.0 THK X 9.0 X 8.0		
														2	-1203		A-FRAME - STL - AF - 10				EXISTING @ETL
		1													-1201		ROD	COLD ROLL STEEL	2.5" HEX BAR X 20.00 LONG		
		2	2														BEARING	HEIM - HA-16			
		1	1												-1105	(3)	ROD END [illegible] THD	4340 STEEL HT (180KSI)	3.0 DIA ROUND BAR X 8.00 LONG		
		1	1												-1103	(3)	ROD END 1/4 THD	4340 STEEL HT (180KSI)	3.0 DIA ROUND BAR X 8.00 LONG		
			1												-1101		ROD	COLD ROLL STEEL	2.5" HEX. BAR X 12.00 LONG		
					1										-905		PLATE, CLEVIS SIDE	HOT ROLL STEEL PLATE	3/4 THK X 3.25 X 3.50	(SEE -900 NOTE 24" LONG)	
				1											-1005		ROD END	—	SOUTHWEST PRODUCTS CO PART NO [illegible]		EXISTING @ETL
				1											-1003		ROD END	—	SOUTHWEST PRODUCTS CO PART NO [illegible]		EXISTING @ETL
				1											-1001		ROD	COLD ROLL STEEL	2.5" HEX BAR X 1[illegible].68 LONG		
					1										-903		PLATE, CLEVIS SIDE	HOT ROLL STEEL PLATE	3/4 THK X 4.25 X 4.50	(SEE -900 NOTE 24" LONG)	
					2										-901		PLATE, CLEVIS		3/4 THK X 3.50 X 3.50	(SEE -900 NOTE 24" LONG)	
						1									-803		PLATE, BASE		3/8 THK X 32.0 X 3.00		
						1									-801		PLATE, VERTICAL		3/8 THK X 32.0 X 4.75		
							1								-703		PLATE, BASE		3/8 THK X 32.0 X 3.00		
							1								-701		PLATE, VERTICAL		3/8 THK X 32.0 X 4.75		
						5	5	6							-605		GUSSET 45°		3/8 THK X 3.0 X 3.0		
								1							-603		PLATE, BASE		3/8 THK X 36.[illegible] X 2.00		
								1							-601		PLATE, VERTICAL		3/8 THK X 36.[illegible] X 4.75		
									6		12				-505		GUSSET △		3/8 THK X 3.00 X 2.25		
									1						-503		PLATE, BASE		3/8 THK X [illegible] X [illegible]		
									1						-501		PLATE, VERTICAL		3/8 THK X [illegible] X 3.70		
										16					-403		STIFFENER	HOT ROLL STEEL PLATE	1/2 THK X 12.6 X 7.0		
										1					-401		BEAM	STRUCTURAL STEEL	W 14 X 87 X 300.0	ASTM-A-36	EXISTING @ETL
											8				-311		PLATE	HOT ROLL STEEL PLATE	3/8 THK X 6.0 X 3.0		
											8				-309		SPACER PLATE	HOT ROLL STEEL PLATE	3/8 THK X 6.0 X 3.0		
											20				-307		SPACER PLATE	HOT ROLL STEEL PLATE	1/2 THK X 10.0 X 1.75		
											2/2				-305/306		CHANNEL	STRUCTURAL STEEL	C10 X 20 X 204.0	ASTM-A-36	
											12				-303		CHANNEL	STRUCTURAL STEEL	C6 X 13 X 54.0	ASTM-A-36	
											1				-301		BED PLATE	HOT ROLL STEEL PLATE	3/8 THK X [illegible]		
												2			-207		GUSSET 45°		3/8 THK X 7.0 X 7.0		
												2			-205		WEB		1/2 THK X [illegible]		
												2			-203		SIDE PLATE		1.0 THK X [illegible] X 18.0		
												2			-201		END PLATE		1.0 THK X [illegible] X 18.0		
												4	4		-107	(2)	STIFFENER		[illegible] THK X [illegible] X 8.0		
													2		-105	(2)	WEB		[illegible] THK X 58.0 X 28.0		
													2		-103	(2)	SIDE PLATE		1.0 THK X 30.0 X 18.0		
													2		-101	(2)	END PLATE	HOT ROLL STEEL PLATE	1.0 THK X [illegible] X 18.0		
														4	-1400	(3)	ASSY - HOLD DOWN				
														2	-1300	(3)	SUB ASSY - CLEVIS				
														2	-1200	(2)	ASSY LATERAL RESTRAINT				
														4	-1100	(2)	ASSY LOADING HEAD ROD				
														4	-1000	(2)	ASSY SPECIMEN ROD				
												6			-900	(3)	SUB ASSY - CLEVIS	FAB AS 1 24 LONG WELDMENT - SAW INTO 6 - 900 ASSYS (O.P. FAB)			
														2	-800	(3)	ASSY - PRESSURE FENCE				
														2	-700	(3)	ASSY - PRESSURE FENCE				
														2	-600	(2)	ASSY PRESSURE FENCE				
														2	-500	(2)	ASSY PRESSURE FENCE				
														2	-400	(3)	ASSY - TENSION BEAM				
														1	-300	(2)	ASSY PRESSURE BED	FAB'D BY O.P. STEEL FABRICATOR		% [illegible] > [illegible] > [illegible] > [illegible] > HOLES	
														1	-200	(2)	ASSY LOADING HEAD	FAB'D BY O.P. STEEL FABRICATOR			
														2	-100	(2)	ASSY REACTION HEAD	FAB'D BY O.P. STEEL FABRICATOR			
															-1		TEST FIXTURE - BASIC ASSY				

QUANTITY REQUIRED

PARTS LIST

... WITH DEVCON "PLASTIC STEEL"
... FOR FIT UP TOLERANCES.
... STRESS OF 25 KSI. ACTUAL
... TO ACCOUNT FOR SPECIMEN
...
...) TO BE LOCATED ON -200 AND
... ALIGNED WITHIN 0.050 ON

... AXES AT 10 LOCATIONS
... PRIOR STAGE.
... LABORATORY FLOOR ON

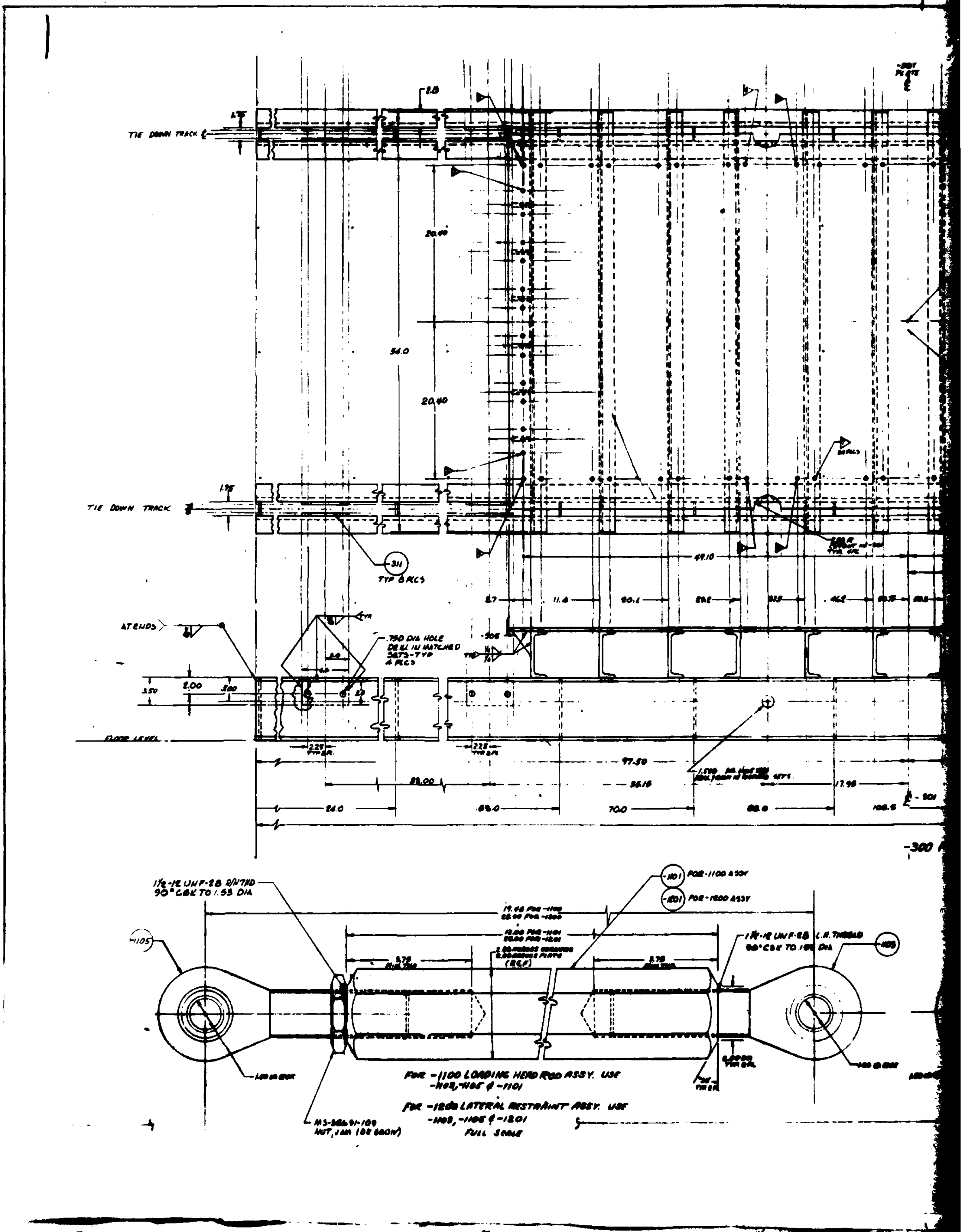
... HYDRAULIC LOAD CYLINDER
... LOAD AXIS W/IN 0.050
... -303 CHANNELS.

... PLATE - HOLE PATTERN
... PRESSURE FENCE
... PLATE - HOLE PATTERN
... PRESSURE FENCE ASSY
... PLATE - HOLE PATTERN
... PRESSURE FENCE ASSY
... PLATE - HOLE PATTERN
... PRESSURE FENCE ASSY.
... USING TEMPLATE PER NOTE 1
... PLATES PER TEMPLATE [illegible];
... -103 SIDE PLATES

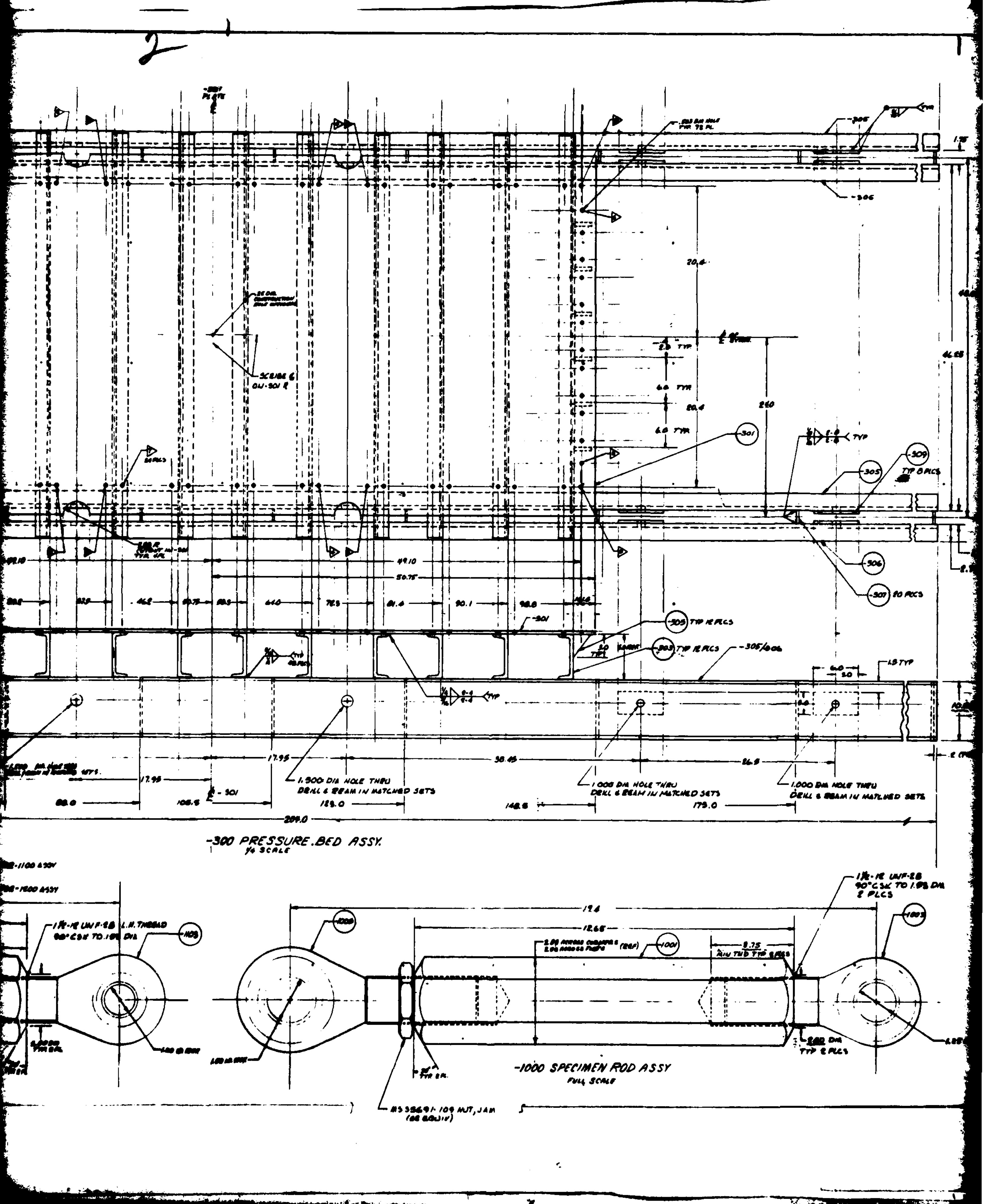
INDUSTRIES, INC.

[illegible] PROGRAM
THREE FA[illegible] [illegible]VEL ELEMENT
[illegible]

501-392

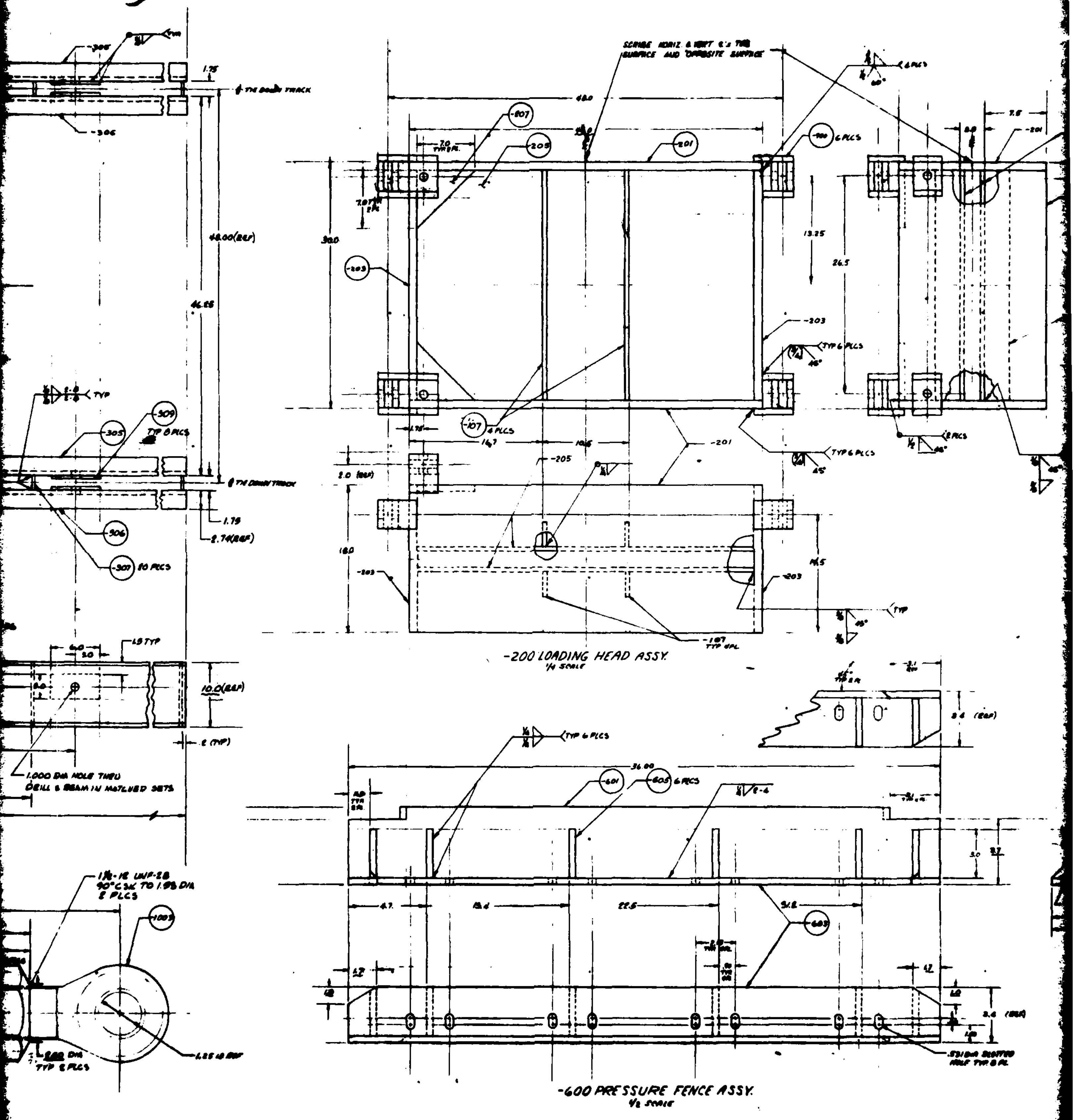


TIE DOWN TRACK
TIE DOWN TRACK
TYP 8 PLCS
AT ENDS
.750 DIA HOLE
DRILL IN MATCHED
SETS-TYP
4 PLCS
FLOOR LEVEL
-300
1½-12 UNF-2B R/H THD
90° CSK TO 1.55 DIA
FOR -1100 ASSY
FOR -1200 ASSY
1½-12 UNF-2B L.H. THREAD
90° CSK TO 1.55 DIA
(REF)
FOR -1100 LOADING HEAD ROD ASSY. USE
-1102, -1105 & -1101
FOR -1200 LATERAL RESTRAINT ASSY. USE
-1102, -1105 & -1201
FULL SCALE
MS-35691-109
NUT, JAM (OR EQUIV)

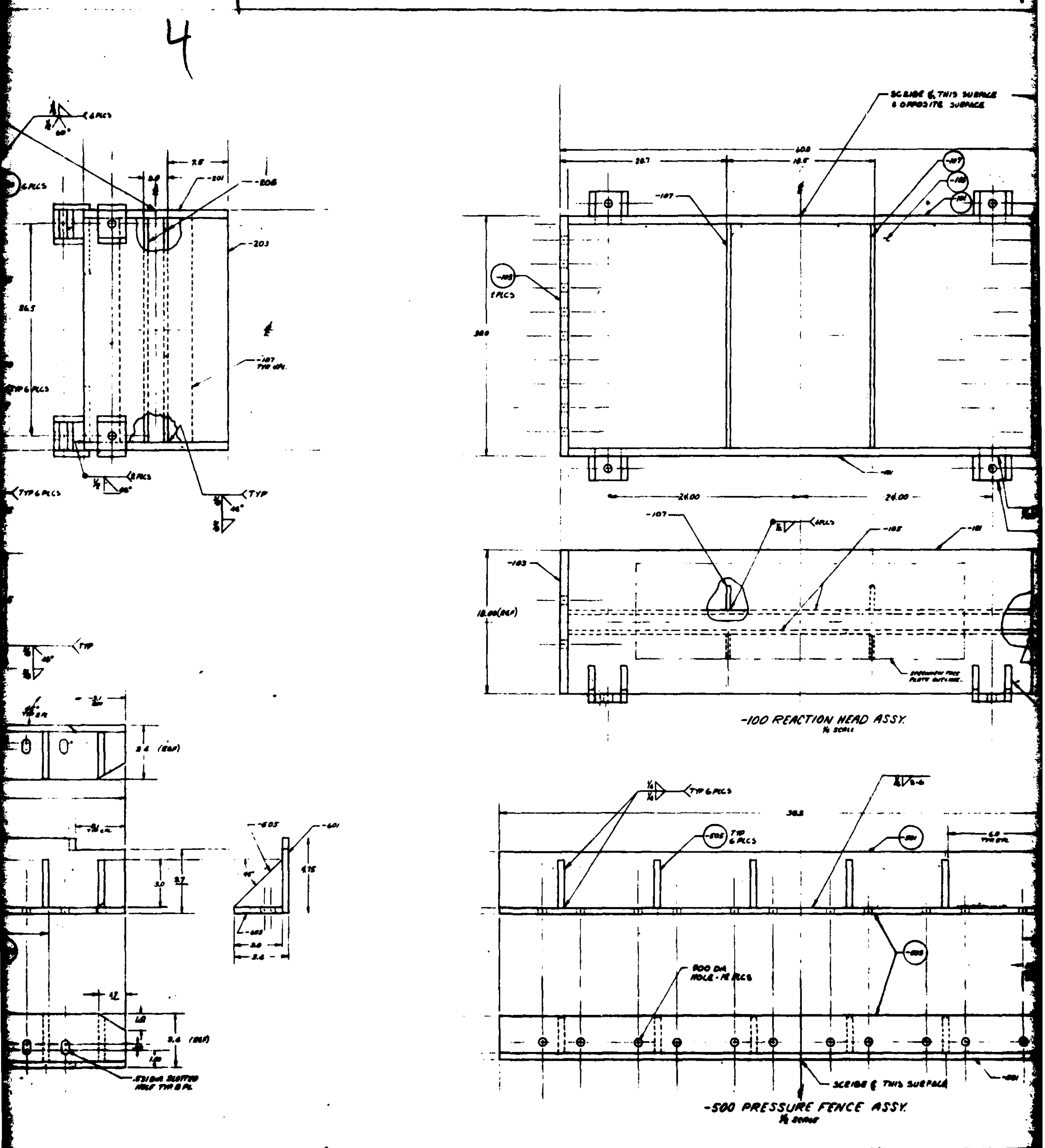


2
-305
-306
20.4
20.4
26.0
2.5 TYP
6.0 TYP
6.0 TYP
-301
-305
-309
TYP 8 PLCS
-306
-307 20 PLCS
SCRIBE ℄ ON -301 ℄
49.10
50.75
46.2
64.0
78.5
81.4
90.1
98.8
-301
-305 TYP 12 PLCS
-303 TYP 12 PLCS
-305/306
1.5 TYP
6.0
3.0
17.95
17.95
38.45
26.5
1.500 DIA HOLE THRU DRILL & REAM IN MATCHED SETS
1.000 DIA HOLE THRU DRILL & REAM IN MATCHED SETS
1.000 DIA HOLE THRU DRILL & REAM IN MATCHED SETS
℄ - 301
88.0
106.5
123.0
148.6
173.0
209.0
-300 PRESSURE BED ASSY.
1/4 SCALE
-1100 ASSY
-1200 ASSY
1½-12 UNF-2B L.H. THREAD 90° CSK TO 1.93 DIA
-1103
1½-12 UNF-2B 90° CSK TO 1.93 DIA 2 PLCS
19.4
12.65
-1003
-1002
-1001
3.75
.280 DIA TYP 2 PLCS
-1000 SPECIMEN ROD ASSY
FULL SCALE
MS35691-109 NUT, JAM

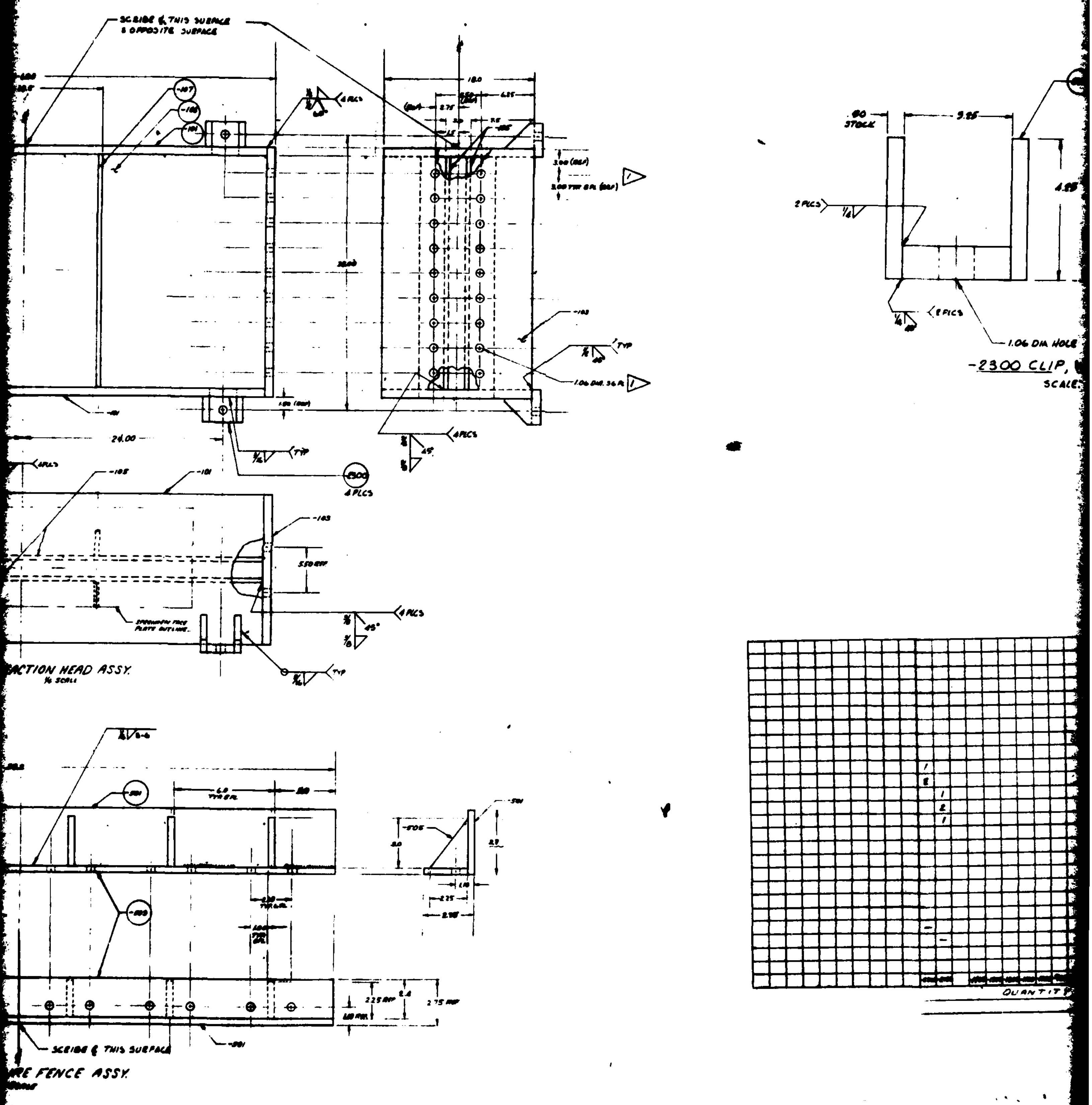
3



SCRIBE HORIZ & VERT ℄'s THIS SURFACE AND OPPOSITE SURFACE
48.00(REF)
46.65
1.75
1.000 DIA HOLE THRU DRILL & REAM IN MATCHED SETS
10.0(REF)
1 1/8-12 UNF-2B 90°CSK TO 1.93 DIA 2 PLCS
-200 LOADING HEAD ASSY.
1/4 SCALE
-600 PRESSURE FENCE ASSY.
1/2 SCALE
.531 DIA SLOTTED HOLE TYP 8 PL

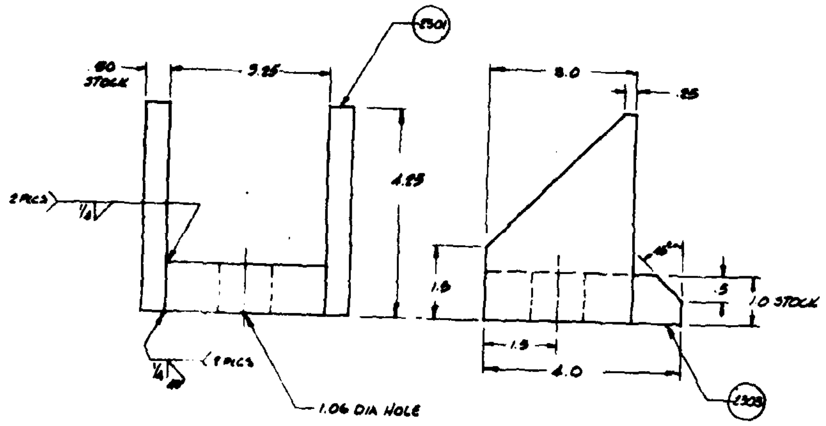

4
SCRIBE ℄ THIS SURFACE & OPPOSITE SURFACE
-100 REACTION HEAD ASSY.
-500 PRESSURE FENCE ASSY.
SCRIBE ℄ THIS SURFACE
TYP 6 PLCS
.531 DIA. SLOTTED HOLE TYP 8 PL
.500 DIA HOLE - 12 PLCS
18.00 (REF)
24.00
24.00

5 1



SCRIBE ℄ THIS SURFACE & OPPOSITE SURFACE
4 PLCS
18.0
STOCK
3.85
2 PLCS
2 PLCS
1.06 DIA HOLE
-2300 CLIP,
SCALE
TYP
1.06 DIA. 36 PL
24.00
4 PLCS
TYP
4 PLCS
550 REF
4 PLCS
TYP
ACTION HEAD ASSY.
½ SCALE
45°
QUANTITY
SCRIBE ℄ THIS SURFACE
RE FENCE ASSY.

6



-2300 CLIP, WELD ASSY
SCALE: 1/1

Qty	Qty	Qty	Qty (-1)	Part Number	Zone	Description	Material	Material Size	Material Spec	Process
			4	-9		PIN	1.65 DIA x 4.0	BAR	AISI 4340	[illegible]
			4	AN960-2016		WASHER				
			4	NAS1022-N20		NUT				
			4	NAS1110-42		BOLT				
			32			HEX-HD CAP SCREW	GRADE 5	½-13UNC x 3 LONG		(MACH'D AFTER[illegible])
			6	NAS1022-N16		NUT	(OR EQUIV)			
			6	NAS1116-40		BOLT				
			6	MS21044-N16		NUT				
			6	AN960-1616		WASHER				
			6	NAS1316-40		BOLT				
			10	MS35691-109		NUT, JAM	(OR EQUIV)			
1				-2300		PLATE	HR STL PL	1 x 6 x 5.25		
2				-2301		GUSSET	HR STL PL	½ x 8 x 4.6		
	1			-2105		NUT, HEX HD	GRADE 8	1-14UN		
	2			-2103		WASHER	FLAT · HARDENED	1⅙ I.D x 2.000 x $^{7}/_{32}$ T	ASTM-A-325	
	1			-2101		HEX HD CAP SCREW	GRADE 8	1-14UN x 6 LONG		
			72	-7		HEX HD CAP SCREW	GRADE 5	½ DIA - 13 UNC x 2½ LONG		
			106	-5		HEX HD NUT	GRADE 5	½ - 13 UNC		
			106	-3		WASHER - FLAT	SAE STD	FOR ½ BOLT		
			12	STL-B-1000	(3)	BOLT				@ ETL
			12	STL-N-1000	(3)	NUT				@ ETL
			4	STL-W-1000	(1)	SPACER				@ ETL
-		4		-2300	(5)	CLIP, WELD ASSY				
	-		72	-2100		ASSY - FASTENING				

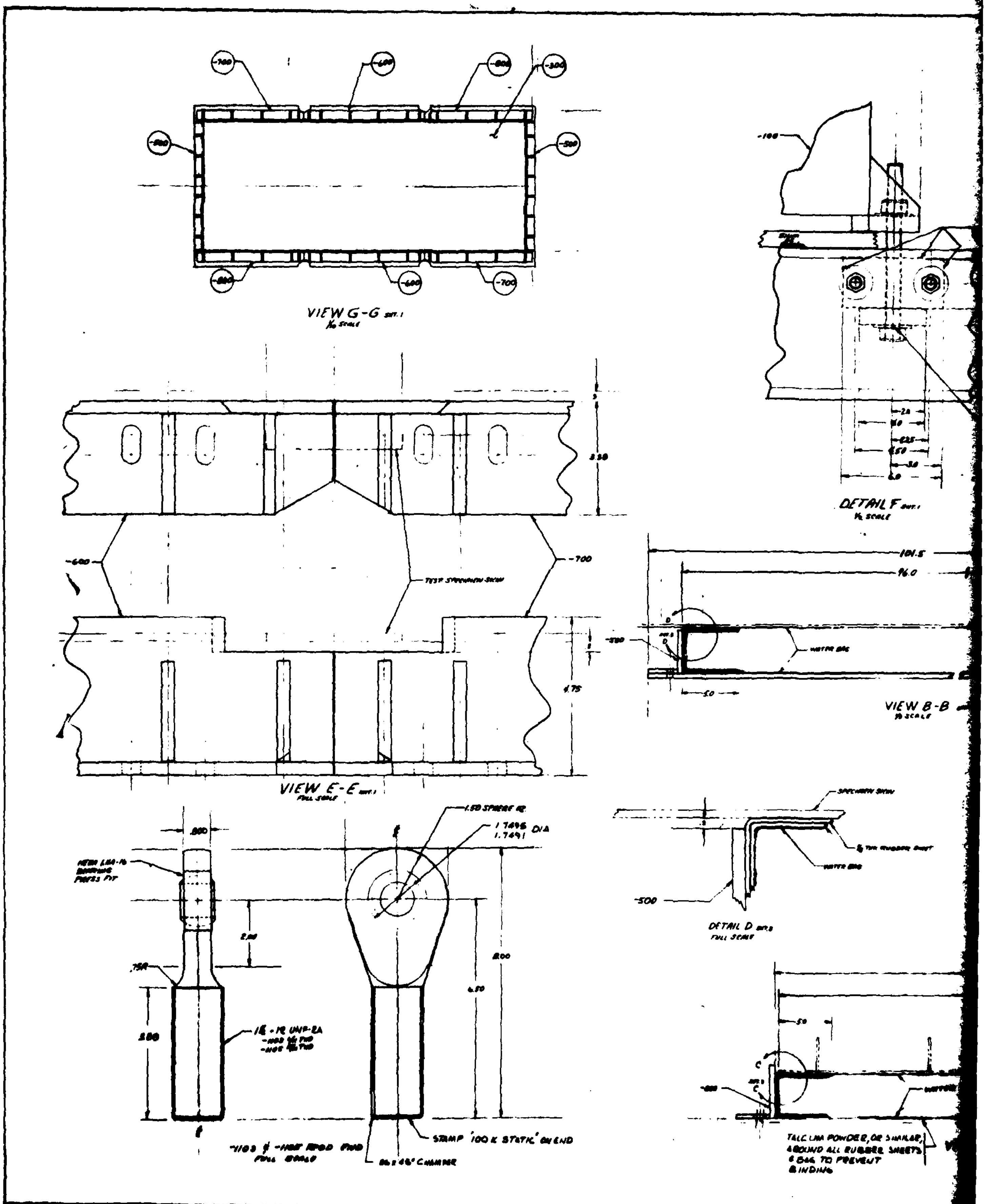
QUANTITY REQUIRED

PARTS LIST

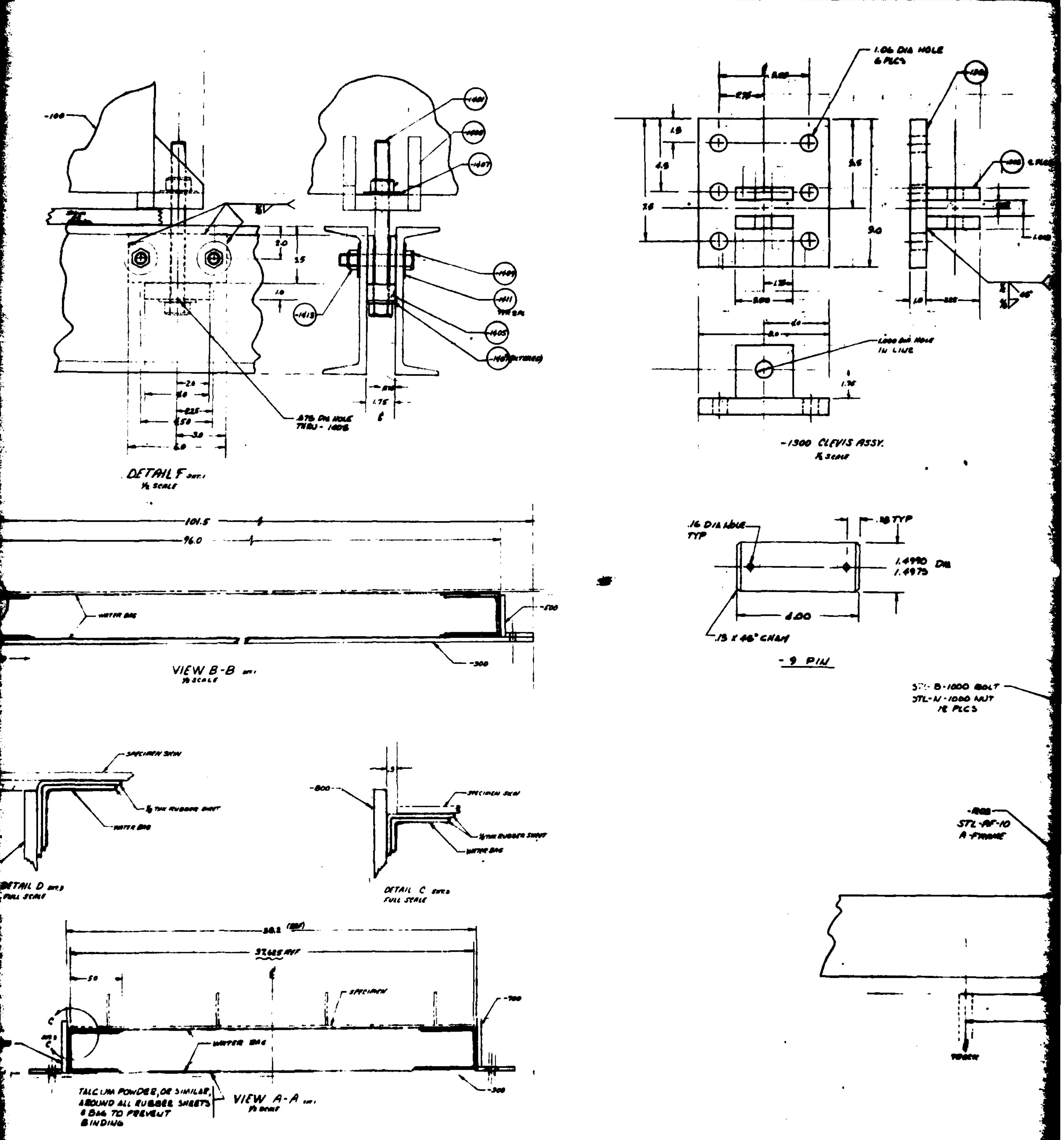
INDUSTRIES, INC.

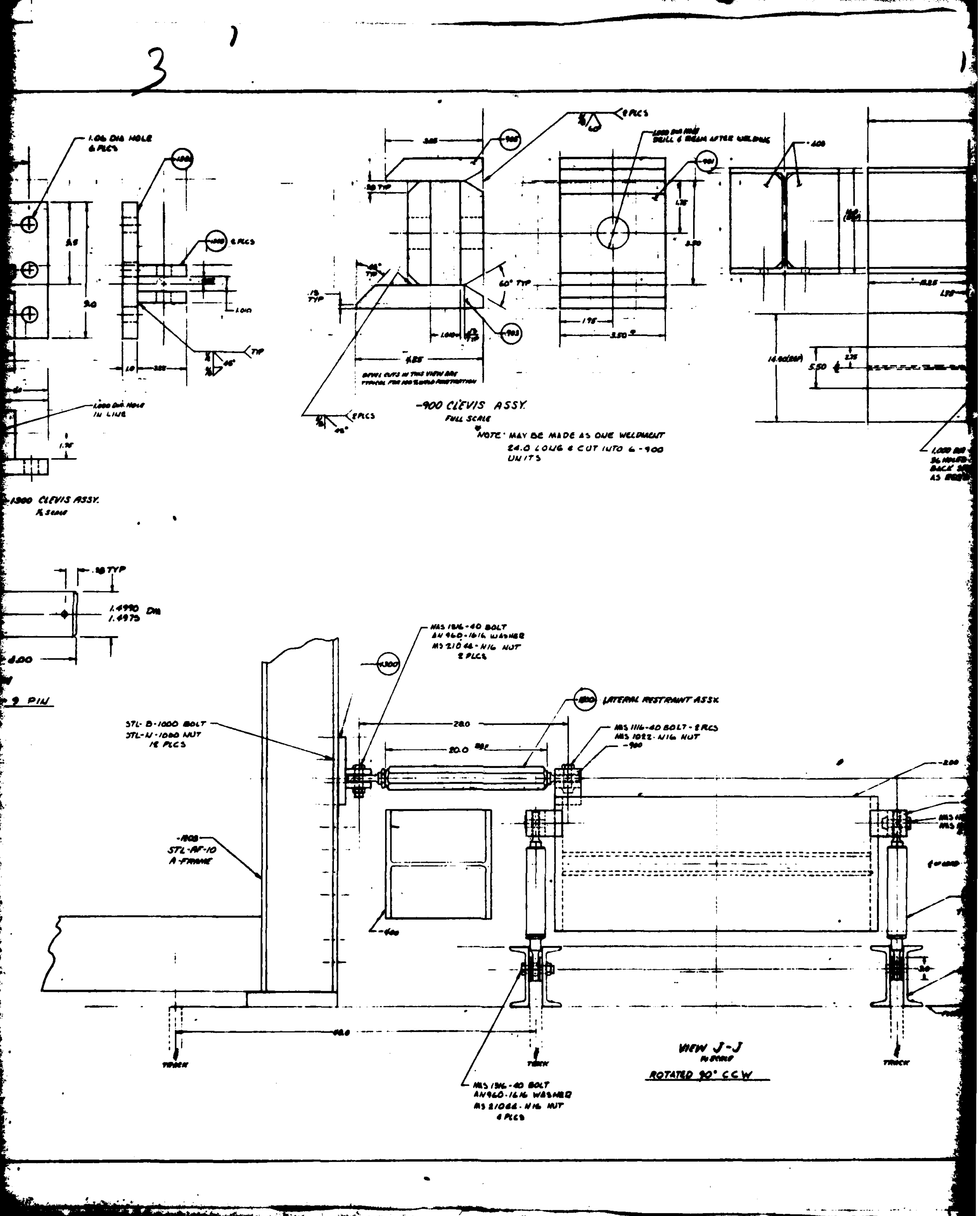
3K SES PROGRAM
THREE WAY PANEL ELEMENT
TEST FIXTURE

501-392


VIEW G-G
DETAIL F
-100
101.5
96.0
WATER BAG
-500
.50
VIEW B-B
-600
-700
TEST SPECIMEN SKIN
3.38
4.75
VIEW E-E
FULL SCALE
.880
1.50 SPHERE R
1.7496
1.7491
DIA
2.00
8.00
6.50
.750
1 1/8-12 UNF-2A
SPECIMEN SKIN
1/8 THK RUBBER SHEET
WATER BAG
-500
DETAIL D
FULL SCALE
STAMP "100 K STATIC" ON END
TALC LIM POWDER, OR SIMILAR, AROUND ALL RUBBER SHEETS & BAG TO PREVENT BINDING

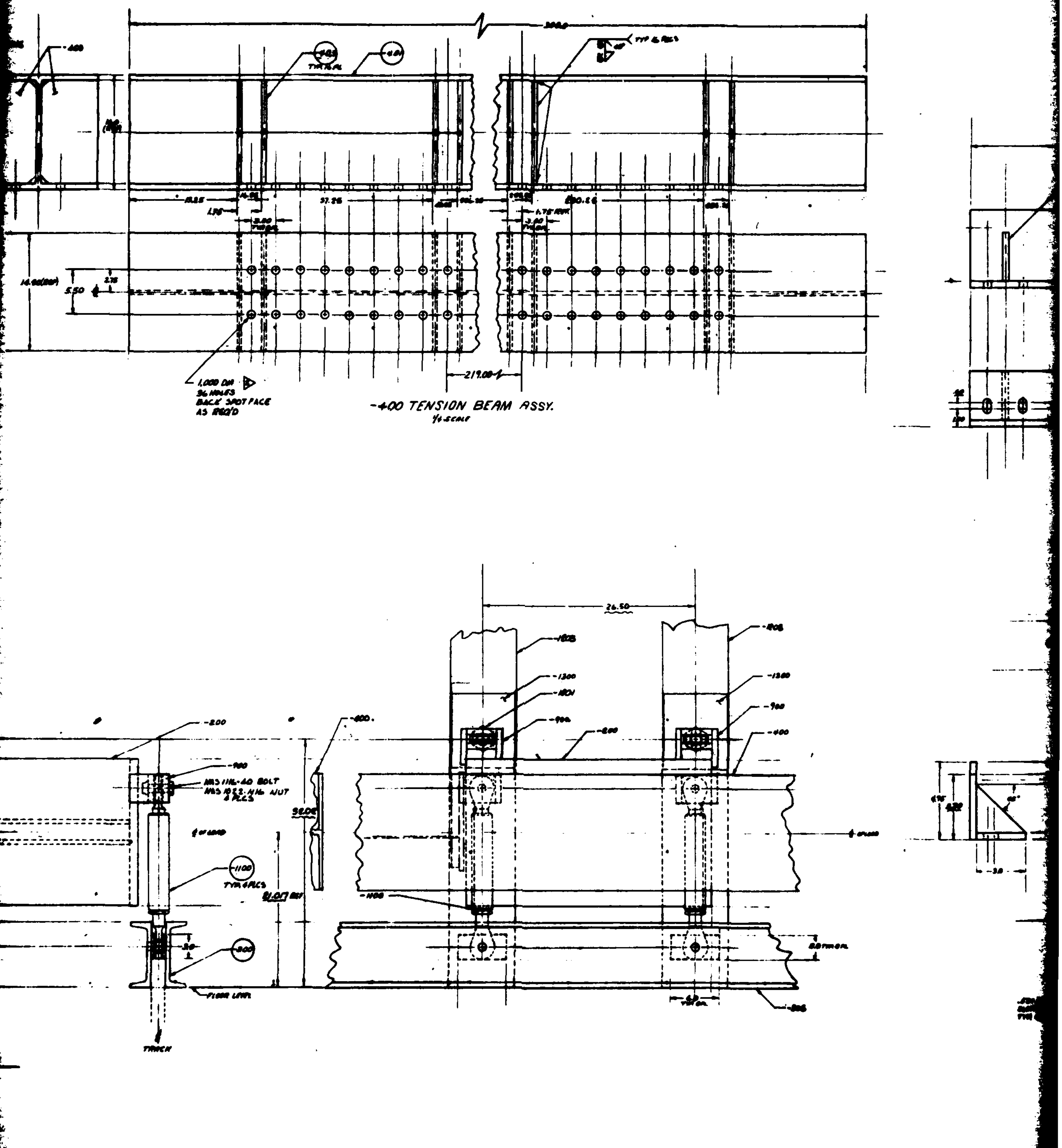
2 1


DETAIL F
½ SCALE
.875 DIA HOLE THRU -1406
-1300 CLEVIS ASSY.
1.06 DIA HOLE 6 PLCS
1.000 DIA HOLE IN LINE
.16 DIA HOLE TYP
.18 TYP
1.4990 DIA
1.4975
4.00
.13 X 45° CHAM
-9 PIN
VIEW B-B
½ SCALE
WATER BAG
STL-B-1000 BOLT
STL-N-1000 NUT
12 PLCS
SPECIMEN SKIN
⅛ THK RUBBER SHEET
WATER BAG
DETAIL D
FULL SCALE
DETAIL C
FULL SCALE
STL-AF-10
A-FRAME
SPECIMEN
WATER BAG
TALCUM POWDER, OR SIMILAR, AROUND ALL RUBBER SHEETS & BAG TO PREVENT BINDING
VIEW A-A
½ SCALE

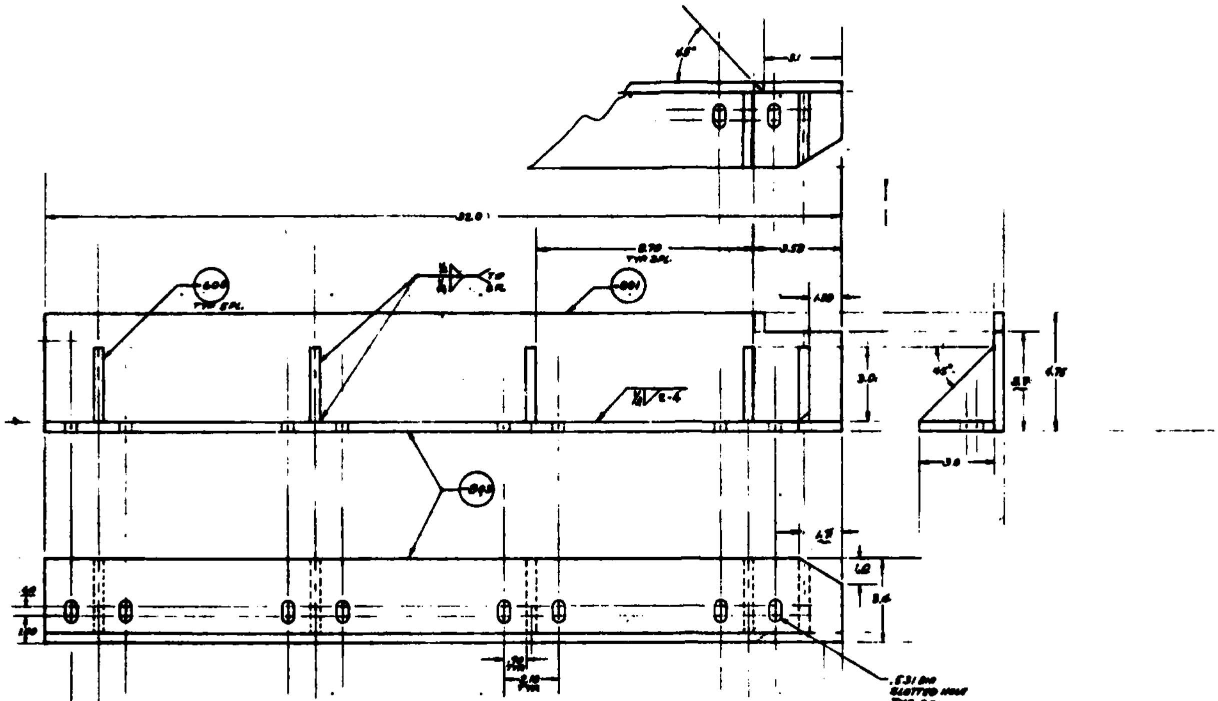


3
1.06 DIA HOLE 6 PLCS
2 PLCS
TYP
1.000 DIA HOLE IN LINE
-1300 CLEVIS ASSY.
-900 CLEVIS ASSY.
FULL SCALE
NOTE: MAY BE MADE AS ONE WELDMENT 24.0 LONG & CUT INTO 6-900 UNITS
60° TYP
.18 TYP
1.4990 DIA
1.4975
4.00
9 PIN
MS 1916-40 BOLT
AN960-1616 WASHER
MS 21044-N16 NUT
2 PLCS
LATERAL RESTRAINT ASSY.
STL-B-1000 BOLT
STL-N-1000 NUT
12 PLCS
28.0
20.0
MS 1116-40 BOLT - 2 PLCS
MS 1022-N16 NUT
-900
-2.00
STL-AF-10
A-FRAME
-400
TRACK
VIEW J-J
ROTATED 90° CCW
MS 1916-40 BOLT
AN960-1616 WASHER
MS 21044-N16 NUT
4 PLCS

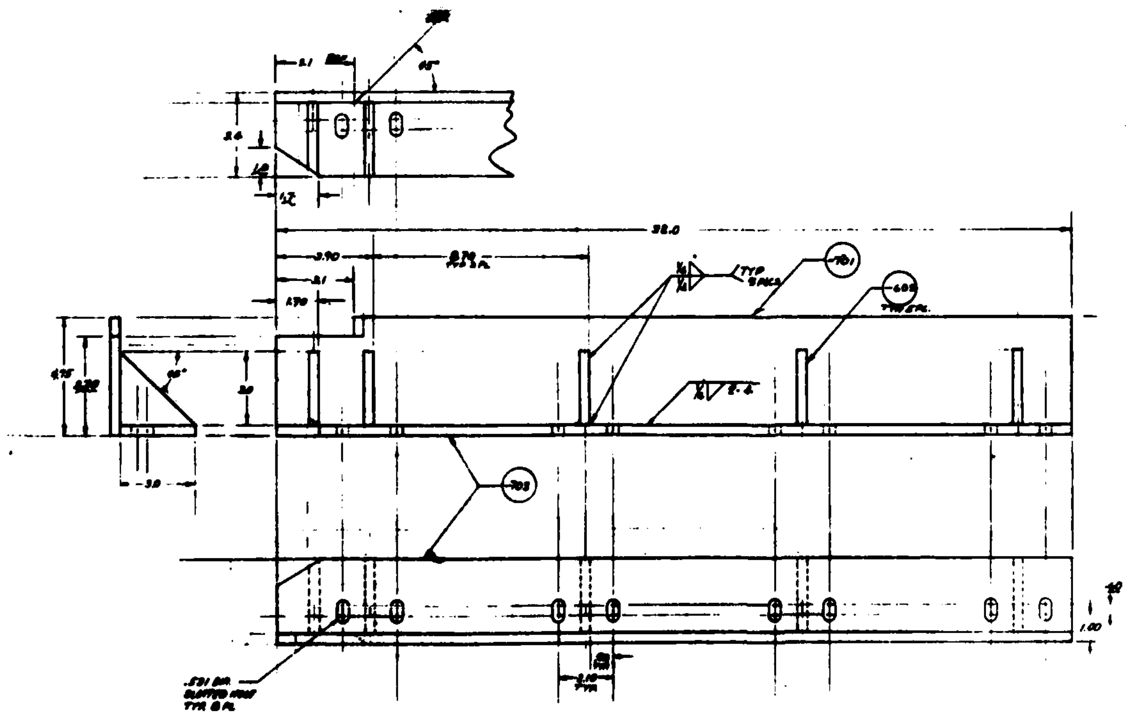
4 1



1,000 DIA
36 HOLES
BACK SPOT FACE
AS REQ'D
-219.00-
-400 TENSION BEAM ASSY.
26.50
MS 1116-40 BOLT
TYP 4 PLCS
FLOOR LEVEL
TRACK



-800 PRESSURE FENCE ASSY.



-700 PRESSURE FENCE ASSY.

INDUSTRIES, INC.

THREE BAY ... ELEMENT TEST FIXTURE

501-392